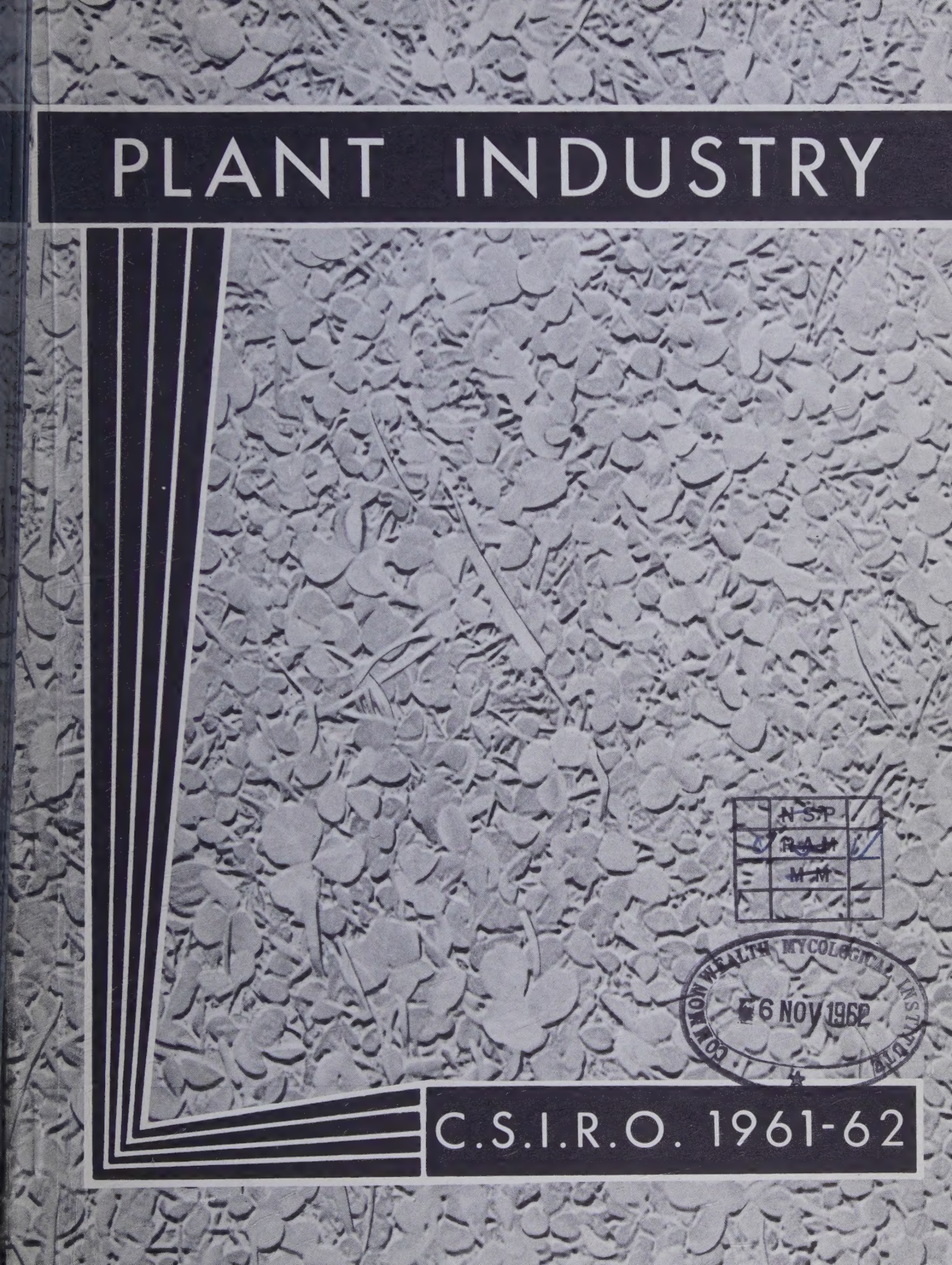
PLANT INDUSTRY



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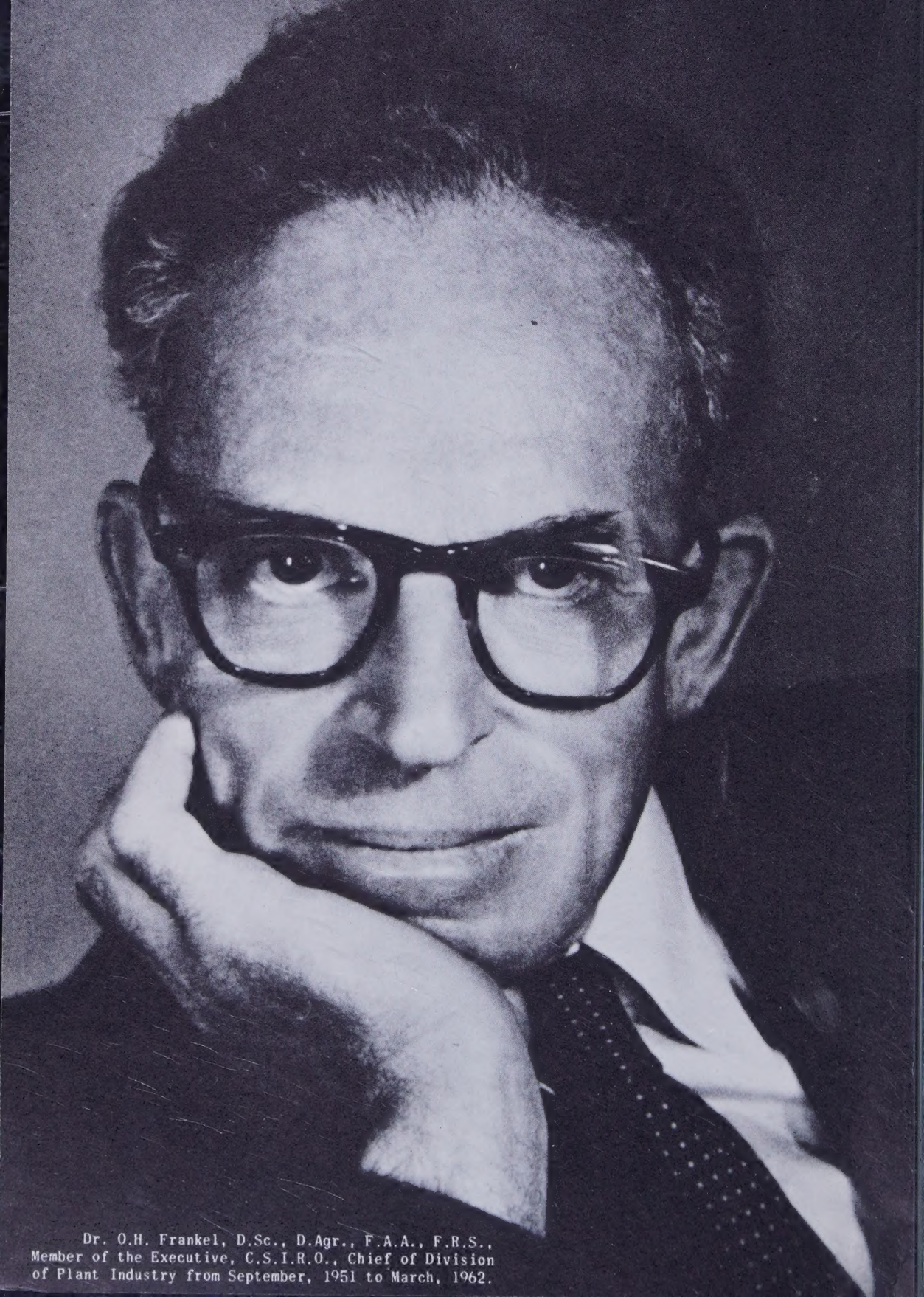

Dr. O.H. Frankel, D.Sc., D.Agr., F.A.A., F.R.S.,
Member of the Executive, C.S.I.R.O., Chief of Division
of Plant Industry from September, 1951 to March, 1962.

ANNUAL REPORT

DIVISION OF PLANT INDUSTRY

1961–62

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Administrative Officer: R. Orchard, A.A.S.A.

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G.P.H.W. Geisler, Ph.D. (Ag.Sc.)
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[oo]Other tobacco studies are conducted within the Genetics and Microbiology Sections in Canberra.

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Administrative Officer:	D.W. Banyard, J.P.
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Senior Administrative Officer:	K.J. Prowse, J.P.
Accountant:	E.E. Petersen, A.A.S.A.

C.S.I.R.O. LIBRARY - CANBERRA

Senior Librarian:	P. Russell

PROGRESS IN RESEARCH

MODERNIZING SELECTION THEORY

Theories of quantitative inheritance, especially those dealing with selection, have been based in the past on simple models of the gene. In recent years the concept of the gene has undergone radical changes. It is now considered a complex unit containing many mutational sites separable by recombination. An attempt is being made to adjust the mathematical theory of selection to accommodate this modern theory of the gene.

A BACTERIOPHAGE CONTAINING RIBOSENUCLEIC ACID (RNA)

An RNA containing bacteriophage has been isolated in Canberra from local sewage. This organism, an extremely primitive one, is one of the smallest living things but is superior to all other RNA viruses so far discovered in respect of purification, handling and assay. With this organism, some progress may be made into the little understood area of biology concerned with the genetics of creatures whose hereditary information is encoded in the RNA molecule.

NATURAL SELECTION IN CYANOGENETIC STRAINS OF WHITE CLOVER

The selective disadvantage of the cyanogenetic system has been found to rest on the property of a hydrolyzing enzyme to be activated by cold treatment such as is provided by a frost. The enzyme thus activated splits the glycoside and releases free hydrocyanic acid. Inhibition of respiration rapidly follows and the growth of glycoside-containing plants is retarded. These interrelations explain the correlation found in Europe between the frequency of white clover plants containing the glycoside and the mean winter temperature. The obverse of this picture, the selective advantage of the cyanogenetic glycoside, is not yet clear. It appears to be bound up with earlier flowering.

THE MOLECULAR AND GENETIC NATURE OF HETEROSIS

Although heterosis (hybrid vigour) is very important in plant breeding and crop production, little is known of its genetic or molecular basis. Experiments with Arabidopsis have shown that a considerable proportion of the heterotic expression for a

character is elicited by the growth temperature. This temperature - heterosis relationship also holds for fluctuating temperatures and for high temperature shocks. These data indicate that heterosis in Arabidopsis results from a combining in the hybrid of the more thermostable alleles of different strains. Such temperature - unstable alleles have been induced by mutation and shown to be a frequent result of mutational events. The molecular expression of the temperature - dependent heterosis rests on the production of unstable enzymes by the affected genes.

MUTATION PLANT BREEDING

Most of the important characters of agricultural plants such as yield, quality, flowering time, are determined, not by single genetic factors, but by the combined action of large numbers of genes each of which has only a small effect. Recent work in the Genetics Section has been directed towards assessing the role of induced mutations in improving such characters.

Irradiation of seeds of Tallarook subterranean clover with X-rays and neutrons generated appreciable variation in flowering time. A second cycle of radiation and selection was applied to early and later flowering mutants which resulted from the first cycle of treatment. Further variability was generated but the additional progress that could be achieved by selection was only twenty per cent. of that achieved in the first cycle. This result suggests that successive cycles of radiation may not be as efficient as following the bursts of radiation with cycles of recombination to utilize more effectively the genetic variation generated by mutation.

BREEDING FOR CREEPING ROOT IN LUCERNE

Conspicuous progress has been made in the lucerne breeding programme aimed at the production of a creeping rooted strain with high summer and winter production. In crosses between the Canadian creeping rooted variety Rambler and the highly productive Hunter River, Hairy Peruvian and African strains, the incidence of creeping plants was only of the order of five per cent., two generations of selection have increased this frequency to forty per cent., and have generated appreciable additive genetic variance for future selection to work on. The pattern of behaviour is readily understood on the basis of a threshold model, the normal processes of root development apparently being buffered against genetic effects tending to disturb them.

Estimation of the genotypic correlations of summer and winter vigour with degree of creep, has indicated that little difficulty will be experienced in recombining the desirable characteristics of the parental strains. In the current season advanced material will be available for evaluation in grazing trials.

ESTIMATION OF GENETIC PARAMETERS IN PHALARIS

The array of introductions of Phalaris tuberosa which have been used in current improvement programmes, show wide variation as regards their mean date of maturity, seed weight and seedling vigour; the three characters are associated to some degree, those introductions which are early-maturing tending to have large seeds and high seedling vigour. From a breeding viewpoint, one is concerned to know whether the observed associations are likely to be broken readily (i.e. whether they are purely ecotypic) or whether physiological relationships will tend to maintain permanent genetic correlations.

The analysis of the established Australian Commercial population, which can be presumed to be in linkage equilibrium, has thrown some useful light on this problem: within this population, maturity time and seed weight have been found to be genetically correlated to some appreciable degree, the later flowering individuals tending on the average to have lighter seeds; and seedling vigour has been found to be virtually independent of flowering time. As was to be expected, seed weight and seedling vigour have been found to be closely associated. Similar studies are in progress with the advanced breeding material derived from the parental introductions.

NEW GRAZING PLANTS FOR SUB-TROPICS

Rarely do we witness the bringing into cultivation of a species never used before. In 1952 the Plant Introduction Section introduced a number of populations of Phaseolus atropurpureus, a species scarcely known to agriculture at that time. Following the success of early plant introduction trials in Brisbane with this species a new variety "Siratro" was bred by Dr. E.M. Hutton of the Division of Tropical Pastures. This grazing legume will soon be commercially available in Queensland.

Following its collection in Kenya in 1951 by Mr. J.F. Miles on a plant collecting mission, a variety of Dolichos lablab C.P.I. 16883, was selected as promising in

nursery trials in Brisbane and supplied to the New South Wales Department of Agriculture at Grafton for trial. Following numerous trials and recommendations by that Department the seed has now become commercially available.

IMPROVED PASTURE ESTABLISHMENT BY BETTER INOCULATION OF LEGUMES

One of the major factors in successful establishment of pasture legumes on soils of low fertility is death of seedlings from nitrogen stress when nodules are not produced on the roots. This may be caused by failure to inoculate the seed in areas from which appropriate nodule bacteria are absent, by premature death of the applied inoculum, or by dry conditions delaying germination of the seed until the inoculum has been reduced to an ineffectual level. Considerable progress has been made in two aspects of this problem.

It has been found that inoculation of pelleted seed with exceedingly high numbers of nodule bacteria by a multi-step process has enabled up to a hundred per cent. nodulation of subterranean and crimson clovers sown on skeletal hill soils where standard commercial inoculation is without effect. The improved establishment followed both machine and aerial sowing of the specially treated seed.

Successful nodulation has been obtained with seed sown into dry soils 3-4½ weeks before germinating rains fell. This was accomplished by incorporating a commercial peat inoculant within a lime pellet. This method shows promise for the dry sowing of legume seed for pasture improvement in semi-arid areas.

OXYGEN - AN INHIBITOR OF SYMBIOTIC NITROGEN FIXATION IN LEGUMES

Experiments with isotopic nitrogen have shown that at high external partial pressures, oxygen is a competitive inhibitor of nitrogen fixation. This is probably due to competition at a common point between the electron transport chains leading to aerobic respiration and to the system in which nitrogen is reduced to ammonia in nodules. These findings suggest that the nitrogen-fixing centres of nodules are anaerobic. This has been confirmed by the finding that the haemoglobin of soybean nodules is less than one per cent. oxygenated. This pigment has a very high affinity for oxygen and the partial pressure within the haemoglobin-containing sub-structures of nodules may be as low as 0.001 per cent. when the external atmosphere is air.

GERMINATION OF PERONOSPORA TABACINA CONIDIA

Germination of spores of Peronospora tabacina in vitro was first reported in 1931, but only recently have cultural conditions been found that allow high levels of germination under reproducible conditions.

Spores, as produced by the fungus, contain an inhibitor that prevents germination. This inhibitor can readily be removed by washing with water. Washed conidia show an absolute requirement for the vitamin, riboflavin, for germination.

On leaves of the susceptible tobacco variety, Virginia Gold, germination is very low (1-4 per cent.), but this rises to 40-45 per cent. in the presence of riboflavin. If the leaves are first washed exhaustively, the degree of germination rises to 90-95 per cent. The gum on the leaf surfaces contains inhibitory material and the distribution of these compounds on the various leaves of the plant correlates with their differential resistance to blue mould, this being highest on the upper leaves, which have the highest amount of inhibitor on their surfaces. The fact that the inhibitory substances can be readily washed off could be of importance in the epidemiology of the fungus and the presence of such inhibitors could affect the rate of spread of the disease in the field.

MICRO AND MACRO NECROTIC INFECTIONS OF TOBACCO MOSAIC VIRUS

It has not been recognized previously that necrotic local lesions due to plant virus infections can be so small that they are only detectable microscopically. Moreover, some lesions which are macroscopically detectable on young leaves are only microscopically detectable on mature leaves. Experiments showed this to be due to the masking of lesions caused by post-inoculation expansion of leaves in association with rapid but limited lesion growth.

The proportion of macroscopically detectable lesions varied with virus strain and size of lesions could be increased by increasing virus concentration. Evidence suggested that variation of lesion size within leaves was due, in part, to heterogeneity of lesion sites.

SUB-LETHAL RADIATION DAMAGE

Experiments with tobacco mosaic virus have shown that ultra-violet irradiation of virus preparations not only kills virus particles but also reduces the rate of multiplication of the survivors. X-irradiation does not produce this effect. The effect appears to be associated with the nucleic acid moiety of the virus suggesting it to be upon the nucleic acid replication process and not upon the stages of entry and attachment of the virus particles to their site of multiplication in the plant cell.

ORGANIC PHOSPHORUS IN SOILS

Organic phosphorus comprises a large fraction of the total phosphorus in soils and has low current availability to plants. Little is known of its true chemical nature or of its origin. Investigations of phytate preparations from soils have shown that they contain in addition to myo-inositol hexaphosphate, dl- and scyllo-inositol hexaphosphate. Lower esters of some or all of these have also been found.

Of the inositol isomers identified in the soil preparations only myo-inositol has previously been found in the phosphorylated form in nature. This indicates a probable soil origin for this group of compounds rather than a plant origin.

AVAILABLE NITROGEN IN PASTURE SOILS

Examination of mineral nitrogen in soils under subterranean clover pastures at Canberra has shown that as fertility increases, as a result of continued superphosphate application and clover growth, a stage is reached when the amount of mineral-nitrogen in the surface soil begins to undergo pronounced seasonal changes leading to distinct mineral-nitrogen accumulation during the summer and autumn. This is in direct contrast to the mineral-nitrogen status in pasture soils overseas where both ammonium- and nitrate-nitrogen have been found to remain at a low level continuously.

The main accumulations occur in the top inch of the surface soil. Nitrate accumulates as a result of increased microbial activity following the wetting of dry soil by rainfall. The time and extent of this summer accumulation is thus determined by climatic factors as they influence the soil moisture content, the intensity of leaching, the duration of drying and the frequency

of rewetting in addition to the total nitrogen status of the soil.

ASSESSING MINERAL DEFICIENCIES IN PLANTS

A most serious obstacle to increasing agricultural and pastoral production is the difficulty of determining which nutrient elements are deficient. A new and very promising approach to this problem has arisen from recent studies aimed at achieving more rapid responses of plants than are normally obtained in field experiments. The method involves the transfer of sample plants from the field to appropriate culture solutions in a glasshouse.

Deficiency of a particular nutrient element in the plant is indicated by the slower growth of plants in solutions lacking that element. Plants which are not deficient in the element continue to grow normally for a few days when transferred from the field to the deficient solutions. By recording changes in leaf area it is possible to distinguish between deficient and non-deficient plants three days after transfer. Recent experiments have shown that the nutrient status of clover plants in respect to the elements phosphorus, sulphur, potassium, calcium, and boron can be assessed in this way.

Important advantages of the method are that it is rapid and that it is based on the actual response of a plant that has grown under the existing nutritional and other environmental conditions in the field.

THE STRUCTURE OF CHLOROPLASTS

Observations by phase contrast and fluorescence microscopy have provided evidence of the internal structure of higher plant chloroplasts. In the living cell chloroplasts are surrounded by a mobile jacket of amorphous material which resembles mitochondria in appearance and behaviour. The swelling patterns of isolated chloroplasts under increasingly hypotonic conditions indicate that this jacket is the only all-encompassing membrane around the chloroplast. Once this has swollen and ruptured the remaining chloroplast behaves as if composed of many individual osmotic units. A model of chloroplast structure has been proposed which combines these observations with what is already known of chloroplast structure from electron micrograph studies. It is proposed that the chloroplast consists of approximately 25 flat sealed bags. Structural continuity between bags is

provided by the grana each of which traverse, and are fused to, a variable number of stroma bags. The whole structure is surrounded by the chloroplast jacket. Most commonly in electron micrograph sections the structural equivalent of the jacket is the outer double membrane.

EFFECT OF NUTRIENT DEFICIENCIES ON CHLOROPLAST STRUCTURE

Recent studies have shown that the nutritional status of higher plants has profound effects on their subcellular organization and structure. Observations using the techniques of phase contrast and flourescence microscopy revealed that a deficiency of manganese leads to a greatly reduced number of chloroplasts in each cell and that within these chloroplasts the distribution of chlorophyll is quite abnormal. Electron micrographs prepared in collaboration with the Botany Department, University of Sydney, showed that in the chloroplasts of manganese-deficient plants the grana (chlorophyll containing structures) are increased in size and greatly reduced in number, while the intergrana lamellae are virtually absent. These observations are consistent with the marked depression manganese deficiency has on photosynthesis. Other large changes in chloroplast structure were found to be specifically associated with a deficiency of the element iron, while many deficiencies led to the formation of chloroplasts that were greatly reduced in size. Available evidence suggests that particular nutrient elements are important in the development of specific cell structures and in some cases are components of these structures.

PROPLASTIDS, THE PRECURSORS OF CHLOROPLASTS

By fluorescence and phase-contrast microscopy, chlorophyll-containing structures (proplastids) have been identified in living cells in sections of dark-grown bean leaves. The proplastids, which are 1/3 to ½ the size of chloroplasts, survive homogenization of the tissue in 0.4M sucrose, sedimentation into a pellet and purification by centrifugation in a sucrose gradient column. Two sharp intensely yellow bands were obtained at positions in the sucrose column corresponding to densities of 1.13 and 1.24. The lower band contained only intact proplastids, apparently completely free of other organelles, and the upper band contained both proplastids and fragments.

Fluorescence and phase-contrast microscopy revealed that the protochlorophyll is confined in the purified proplastids, to small discrete bodies 0.7 - 1.3μ in diameter and located at

random within a transparent bag, 3-5μ in diameter.

Studies on the development of plastid structure and of photochemical activity following illumination of dark-grown leaves, are being carried out.

MODE OF ACTION OF ANTIFUNGAL AND ANTIBACTERIAL CHELATING AGENTS

Of the many thousands of known chelating agents, a few, for example 8-hydroxyquinoline, diethyldithiocarbamate, kojic acid, are powerful antifungals or antibacterials, but this activity is found only in the presence of iron or copper ions.

It has now been found that the same chelators which have this biological activity, and only these, can catalyze the incorporation of metals into porphyrins. There is thus a strong inference that the biological activity of the chelators may be due to their catalytic interference with the formation of the metalloporphyrins, which are essential components of living cells of all types. Further insight into this question is being sought in several ways.

Enzyme systems which catalyze the incorporation of iron into porphyrins (haem formation) have been obtained in soluble state from liver mitochondria and from a number of micro-organisms. Ferrous ions and anaerobic conditions are both obligatory for the activity of this enzyme system, which has also been found to incorporate the metal ion into porphyrins, not into their reduced forms (phorphyrinogens) which are the active intermediates at earlier stages of haem biosynthesis. There are indications also that in different tissues there are probably a number of enzymes with similar activity, but with specificity towards different porphyrins.

8-hydroxyquinoline was found to inhibit the incorporation of iron into porphyrins by such enzymic preparations. On the other hand, at concentrations at which it was fungicidal, copper-diethyldithiocarbamate did not inhibit haem formation. Whether the catalysis of haem formation by the chelators is in fact related to their antimicrobial activity should become clear as the investigation proceeds.

A LINK BETWEEN PHOTOSYNTHESIS AND PERMEABILITY IN PLANT CELLS

Following an accidental observation, it has been established that under some natural conditions, light has a profound effect on the electrical properties of the membrane of some plant

cells. It has been shown that the effect is connected with photosynthesis, and requires bicarbonate ions. It opens up a biophysical and biochemical approach to the problem of the use of bicarbonate ions by plant cells as a substitute for carbon dioxide. From the more general point of view it is a striking case of the metabolic control of the passive physical properties of cell membranes, and the mechanism of this control will be of considerable interest.

QUATERNARY ECOLOGY

Evidence is accumulating that despite the ancient topography, many present-day plant communities and soils in Australia are young and have undergone a complex evolution during the last few thousand years. Field studies and C14 dating of varves, peats, sedimentary deposits, buried soils, and fossil landscape features in the Monaro Region indicate the following sequence of events. Twenty thousand years ago the Kosciusko summit area was generally glaciated and periglacial conditions extended down to at least 3,000 feet above sea level. These conditions began to ameliorate about 16,000 years ago but small glaciers persisted for a further 5,000 - 6,000 years. Milder conditions continued for several thousand years, until 4,000 - 5,000 years before present when there was a renewal of periglacial activity at the higher levels. The present relatively mild interval has existed for 2,000 - 3,000 years.

This rapid sequence of climatic changes must have produced substantial changes in vegetation patterns, and the existing communities are thought to be young, although many of the species are old. Some sites contain sequences of identifiable plant remains from which it is hoped that the evolution of the vegetation can be reconstructed.

NATURAL PHYTOTOXINS IN RAIN FORESTS

It has been found that, in pure stands, trees of Grevillea robusta prevent the growth of their own but not of other species. Field and glasshouse experiments suggest that actively growing roots of G. robusta produce a water-soluble toxin which causes characteristic physiological lesions in seedlings. These investigations, together with similar studies of other non-gregarious species, may help to explain the distribution of rain forest species, and lead to the detection of biologically active compounds of therapeutic value.

PROMISING PASTURE GRASS

Brignoles cocksfoot (Dactylis glomerata), which originated in the south of France, is showing promise as a pasture grass having a greater capacity for winter production than Phalaris tuberosa. Sheep grazing cocksfoot during the winter may show 15-20 per cent. increase in liveweight and wool yield over those on Phalaris pasture. Under the management conditions imposed, however, cocksfoot was less persistent than Phalaris. In preliminary trials, this strain of cocksfoot has also proved superior to Phalaris in the control of Scotch thistle (Onopordum spp.), but its effectiveness under grazing has yet to be determined.

ECOLOGY OF WEEDS

Recently completed experiments have shown that competition by pasture species can lead to considerable reductions in the density of serrated tussock (Nassella trichotoma) or bracken (Pteridium esculentum) on non-arable land, provided that superphosphate is used. Subterranean clover or volunteer clovers are effective against serrated tussock, especially where tussock density has already been reduced by applying 2,2-DPA to regrowth following burning or desiccation with diquat. Akaroa cocksfoot (Dactylis glomerata) appears to be effective against bracken under conditions of high rainfall and high soil fertility. Bracken density can also be reduced for at least two years by applying 4-CPA, but this does not enhance the effect of the cocksfoot.

More intensive studies of competition between pasture species and bracken have now been started, with emphasis on underground relationships. Future studies of serrated tussock will deal with the factors favouring the growth of this weed, with a view to estimating its potential distribution in Australia.

SILICIFICATION OF THE OAT PLANT

It has been recognized for a long time that some plants, particularly the monocotyledons, absorb large amounts of silicon which is deposited as silica in epidermal cells. A technique has now been developed by which it is possible to separate composite particles of silica from a plant without damaging the structure or altering the composition of the particles. Detailed studies of silica from the vegetative and reproductive parts of the mature oat have revealed that the walls of all types of epidermal cells except cork cells are impregnated with silica. Walls of cells in the hypodermal layer, vessels and fibres are also

impregnated as are those of tracheids in the roots. The impregnating silica is invariably opal and some fine details of the structure suggest that the silica is deposited in intimate association with the cell wall.

CLOVER INFERTILITY

Sheep infertility and lambing losses due to the consumption of oestrogenic compounds in subterranean clover, are still causing concern in Western Australia. Recent bio-assay studies, both with sheep and with mice, point to differences between sub. clover strains in respect of oestrogenic potency. This work, if confirmed, opens up a new way of attempting to combat the clover infertility problem by the use of strains which are free of (or low in) oestrogens.

BITTER PIT AND CALCIUM SPRAYS

Continued work with calcium sprays has given good results for four years in reducing bitter pit by at least fifteen per cent. Tests with a wide range of calcium sources have failed to find anything superior to calcium nitrate. Tests on time and frequency of application indicate that, under Tasmanian conditions, for a given frequency and interval, the later the spray schedule starts the better the effect, and for a common starting date, the more sprays in the schedule the better. Western Australian workers however, find early sprays more effective than later ones.

A further indication that lack of calcium is one of the primary causes of susceptibility to pit has been developed of severe symptoms on fruit trees in sand culture when calcium is omitted from the nutrient solution.

RHYTHM IN CROPPING AND FRUIT CELL NUMBERS

The rhythm of alternating heavy and light crops in deciduous fruits is a well-known horticultural problem. It has now been established that the cropping rhythm is accompanied by a rhythm in the cell numbers in the fruits. A plot of Jonathan apple trees has been under observation since 1952: For the period 1952-1955 the crops were steady and there was no rhythm in cell numbers. In 1956 there was an exceptionally heavy crop and this initiated a rhythm of light crops in the subsequent "odd" years. The thirty per cent. fewer fruits borne in the light crop years had twenty per cent. fewer cells per fruit.

GENERAL

DR. O.H. FRANKEL

Dr. O.H. Frankel was appointed a member of the Executive of C.S.I.R.O. in March 1962 after having been Chief of the Division since 1951.

He was born in Vienna and obtained a Doctorate in Agriculture in 1925 from the Institute of Genetics in Berlin. After carrying out research in Czechoslovakia, Israel, and Great Britain, he went to New Zealand in 1929 to join the Wheat Research Institute of the Department of Scientific and Industrial Research.

During his 22 years in New Zealand, Dr. Frankel made outstanding contributions to science and to the welfare of the country's wheat industry. He was associated with the breeding of every variety of wheat now being grown in New Zealand. In 1942, he became Director of the Wheat Research Institute, and in 1949, Director of D.S.I.R.'s Crop Research Division.

Under Dr. Frankel's leadership the Division of Plant Industry which is the largest in C.S.I.R.O., has become one of the foremost centres for plant research. He has attracted research workers of the highest calibre to the Division and built up strong teams of scientists working in all the important fields related to plant production.

His outstanding contributions to the science of genetics were recognized by his election to a Fellowship of the Royal Society of London in 1953. Among Dr. Frankel's many other scientific honours and distinctions are a Doctorate of Science from the University of New Zealand and a Fellowship of the Royal Society of New Zealand.

He is a Fellow and Former Vice-President of the Australian Academy of Science and was a member of the Council of the Australian National University.

Dr. Frankel has always been interested in the international aspects of plant science. He was an Australian delegate to the 1959 F.A.O. Conference, and he is a member of the Research Committee of the F.A.O. "Freedom from Hunger" campaign.

Dr. Frankel who has been appointed an Honoary Research Fellow of the Division, will continue his personal research with a small group in Canberra on the genetics of flower formation in wheat.

A personal tribute

Dr. O.H. Frankel was reluctant to take on the job of Chief of the Division; but the persuasive powers of the late Sir Ian Clunies Ross prevailed.

The Division was soon disarmed by his energy, his candour, and his obvious desire to do his very best for Plant Industry and to get the very best from Plant Industry. Some people were shaken by the inevitable challenge to explain (and, sometimes, to defend) the line of their researches, but most were grateful for his personal interest and encouragement.

During his regime the character of the Division has changed appreciably. The changes are, of course, due largely to Dr. Frankel, but they are not the expression of personal idiosyncrasy on his part: they reflect the developing image of the plant research centre which seems best fitted to serve a nation's agriculture as a whole. The direction of development of Plant Industry under Dr. Frankel has been essentially parallel to that of major plant research institutes in other countries with an advanced agriculture. Strong specialist sections have been formed in which studies are directed towards basic aspects of national agricultural problems; interaction between the specialist sections and field workers is encouraged to ensure that the specialists do not lose sight of the practical problem, and that their techniques and advice are available to the man in the field.

The Controlled Environment Research Laboratory (CERES) to be opened shortly, is the brainchild of Dr. Frankel. This laboratory, completed at the end of his time as Chief, is a fitting physical monument to him; though, undoubtedly, he takes far greater pleasure in the intellectual climate he has nurtured than in mere buildings.

Perhaps the greatest benefit the Division has received from Dr. Frankel is that of his personal example of intelligence, courage, generosity, and urbane wit. Few men are called on to undertake such a complex and demanding job. Few indeed have the qualities to defend intellectual standards with so little compromise.

DR. H.R. ANGELL, O.B.E.

With the retirement in June, 1962 of Dr. Herbert Raleigh Angell, the Division lost one of its oldest members. In 1928, Dr. Angell, who was with the Division for over 34 years, joined what was then known as the Division of Economic Botany immediately after taking his Ph.D. from McGill University.

Dr. Angell, a pathologist, was one of the three original sectional heads of the Division; his two other colleagues were Dr. J.R.A. McMillan, now Professor of Agriculture in the University of Sydney and the late Dr. Alexander McTaggart, first head of Plant Introduction.

During his long service with C.S.I.R.O., Dr. Angell contributed numerous research papers on various aspects of plant pathology. His interests were many and varied, and included Take All disease of wheat, gummosis of apricots, brown rot of stone fruits and damping-off diseases of seed beds. Perhaps his most important contribution was on blue mould of tobacco. His work with A.V. Hill and J.M. Allen on the control of blue mould in tobacco seed beds by treatment with benzol gained him world renown. This work, one of the first major scientific and industrial achievements of the Division, proved of great value to the Tobacco Industry, and Dr. Angell's outstanding contribution was recognized by his appointment as an Officer of the Order of the British Empire.

In all his research Dr. Angell exhibited very acute powers of observation and it is perhaps for this reason that some of his best work was done in the field. An indefatigable experimenter, he was never afraid of unorthodoxy and in many respects his philosophy on plant disease was ahead of its time. For example, he early became imbued with the importance of the soil environment and the nutrient status of the plant in determining the susceptibility of host plants to fungal attack. Many of his ideas are now being verified experimentally.

Not the least of Dr. Angell's contributions came after his "official" retirement from full-time research in July, 1958. At the request of the Federated Tobacco Growers' Association he continued as a Research Associate of the Division to advise growers on the control of blue mould in the field. His advice on seed bed and crop hygiene is reputed to have saved growers many thousands of pounds.

Dr. Angell is held in affection and respect by all his colleagues who wish him a long and happy retirement.

WILLIAM HARTLEY, B.A.

Another original member of the Division, Mr. William Hartley, left this year to accept the post of Chief Australian Liaison Officer in the U.S.A. He joined the Division after graduating from Cambridge and took up duty with the Plant Introduction Section in 1930. Excepting two years (1938-40), spent at the Herbarium of the Royal Botanic Gardens, Kew, he had been continuously with the Division's Plant Introduction Section. First working under Dr. Alexander McTaggart, he became Officer-in-Charge of Plant Introduction in 1944, holding this post until his departure for Washington this year.

William Hartley's viewpoint was that a Plant Introduction service should not only seek plants of potential agricultural use, but should test them in as many different kinds of environment as possible. The research of his Section, therefore, was directed to Plant Geography - his own interest - and to Agronomy. He recognized the importance of regional testing and established a number of plant introduction centres throughout Australia. A strong protagonist of introduction by exploration and plant collection, he organized a number of expeditions to the Mediterranean, Africa and South America, participating himself in one to the last named country.

As Head of the Plant Introduction Section, William Hartley rendered distinguished service to C.S.I.R.O., and to Australian agriculture, and in so doing, gained a world-wide reputation. In many respects his organization of plant introduction is regarded as a model and this is evidenced by the large number of Colombo Plan and F.A.O. Fellows sent to Australia for training in plant introduction methodology. In 1956 he was invited to be Chairman of a conference convened for the purpose of discussing the role of F.A.O. in the organization of plant exploration. Again in July, 1961, he was elected Chairman of an F.A.O. Technical Meeting on plant exploration.

William Hartley had a unique position in C.S.I.R.O., in that part of his work was of a service nature to other organizations. The many expressions of regret at his departure are evidence of the courtesy and tact he employed in his relations with others.

During the past few years William Hartley has been particularly interested in the world distribution of the tribes of the Gramineae and published a series of papers on their origin and evolution.

A kind and helpful colleague, William Hartley will be missed by his many friends in the Division.

HONOURS, AWARDS AND HIGHER DEGREES

Dr. O.H. Frankel has been awarded the 1962 Farrer Memorial medal by the Farrier Memorial Trust. The medal is awarded for outstanding service to Australian Agricultural Science.

Dr. J.R. Freney awarded the degree of Doctor of Philosophy by the University of New England. Thesis entitled "Sulphur compounds in soil and their conversion to forms available for plant growth".

Mr. J. Lipsett awarded the degree of Master of Agricultural Science by the University of Queensland. Thesis entitled "The effect of red brown earth soils in southern New South Wales, with particular reference to nitrogen and phosphorus status and competition for skeleton weed".

Dr. Angela A. Milne was admitted to the degree of Master of Science without examination by the University of Melbourne.

RESIGNATIONS AND TRANSFERS

Dr. D.W. Goodall, who was the Director of the Tobacco Research Institute at Mareeba, Queensland, from late 1956 has transferred to the Division of Mathematical Statistics at the Western Australian Regional Laboratory, Perth.

Dr. J.V. Possingham who joined the Plant Nutrition Section in 1952 has been appointed Officer-in-Charge of the Commonwealth Research Station at Merbein, Victoria.

Mr. N.E. Rider has completed a three-year Research Fellowship in micrometeorology with the Agricultural Physics Section. He has returned to the British Meteorological Office in Bracknell, Berks.

Mr. R. Roe has been transferred to the Division of Tropical Pastures. He joined the Division in 1936 and was for many years the senior Plant Industry officer at the Regional Pastoral Laboratory at Armidale.

APPOINTMENTS

Dr. J.E. Falk, Head of the Biochemistry Section was appointed an Assistant Chief of the Division.

Dr. C. Barnard who has been on the staff of the Organization for thirtyfive years and of the Division for thirtytwo years, has been appointed Head of the Plant Introduction Section in succession to Mr. W. Hartley.

Dr. L.T. Evans of the Plant Physiology Section has been appointed Officer-in-Charge of CERES (Controlled Environment Research Laboratory).

Mr. W.J. Lovett has been appointed Officer-in-Charge of the Tobacco Research Institute at Mareeba, Queensland. He has been engaged on tobacco research in the Division since 1948.

The following research appointments were made during the year:-

To Canberra, A.C.T.

Dr. Sylvia N. Binns	Biochemistry
Mr. M.I. Bruce	Biochemistry
Mr. H.W. Chapman	Grassland Agronomy
Dr. O.T. Denmead	Agricultural Physics
Mr. I.R. Franklin	Genetics
Dr. M. Freer	Grassland Agronomy
Dr. D.M. Langbridge	Biochemistry
Miss S. Lewis	Genetics
Dr. D.N. Munns	Plant Nutrition
Mrs. J.L. Strong	Plant Introduction
Dr. K.L. Temple	Biochemistry
Dr. E.A. Schwinghamer	Genetics
Dr. J.S. Wilson	Biochemistry
Mr. B.H. Wall	Biochemistry

To Deniliquin, N.S.W.

Mr. R.I. Baxter	Engineering
Dr. R.L. Burt	Plant Physiology
Dr. J.H. Leigh	Ecology
Dr. A. Rixon	Soil Fertility
Dr. J. Warren Wilson	Ecology
Mrs. J. Warren Wilson	Honorary Research Associate

To Waste Point, N.S.W.

Mr. R.N. Cromer	Alpine Ecology

To Armidale, N.S.W.

Dr. R.L. Davidson	Pasture Ecology

To Mareeba, Qld.

Dr. J.M. Hopkinson	Plant Physiology
Dr. P.K. Macnicol	Plant Physiology

GRANTS IN AID OF RESEARCH

A grant of £13,600 per annum, initially for three years, has been given through the Commonwealth Wheat Industry Research Council to enable the Division to undertake research on Skeleton Weed. Two projects will be supported by this grant (i) the ecology of skeleton weed and (ii) physiological and biochemical research on new type weed killers.

The Dairy Produce Research Committee has made a grant of £6,100 per annum, initially for three years, to carry out investigations into the efficient use of fertilizers on the light textured soils in the dairying areas of Western Australia.

A grant of £1,800 has been received to support research in the Plant Nutrition Section as a result of an agreement reached between C.S.I.R.O. and the Sulphur Institute of Washington, D.C. The grant is to further the study of differential changes in plant development upon removal of nutritional stresses, as a means of diagnosing nutrient element deficiencies, with special reference to the element sulphur.

The Colonial Sugar Refining Company Ltd., have made a donation of £500 for research in genetics.

Eight research appointments have been made to work on programmes supported by the following grants announced in last year's Annual Report: Joint grant by Fisons Pest Control Ltd., and J.J.R. Geigy of Basle, Switzerland; Joint grant by the Mining Research Association, C.S.I.R.O. and the Commonwealth Bureau of Mineral Resources; the International Atomic Energy Agency and the Victorian Anti-Cancer Council.

COLLABORATION WITH THE UNIVERSITIES

The Division is closely associated with the various Universities in many of its research programmes. In addition, Divisional Officers have continued to assist in University teaching work by giving courses of lectures in specialized fields of study.

Grants were made during the year to support the following specific projects arising from collaborative work with officers of the Division:-

The ultra structure of mineral deficient chloroplasts - Professor F.V. Mercer, Botany School, University of Sydney.

Tissue and cell culture studies - Dr. D. Dougall, Biochemistry School, University of Sydney.

Analyses and Wool measurements - Dr. W. McManus, School of Wool Technology, University of New South Wales.

CONTROLLED ENVIRONMENT LABORATORY (CERES)

Construction of the Controlled Environment Laboratory (CERES), previously called the phytotron, in Canberra, was virtually completed during the year. The project consists of a large number of cabinets in which plants can be grown under a wide range of controlled conditions.

The Canberra project differs from phytotrons elsewhere in the world in a number of major features such as the greater use of natural light and in the use of cabinets rather than rooms. These allow for the provision of closer control, a wider range of environmental conditions as well as great flexibility in both biological and engineering terms.

The Commonwealth Government announced its decision to finance the building of CERES in 1958 after preliminary development and planning by the Engineering Section of C.S.I.R.O. in collaboration with the Physiology Section of the Division. Prototype cabinets have been under development and continuous test since 1958.

The architects in charge of the project are Messrs Grounds, Romberg and Boyd, with W.E. Bassett and Associates as consulting engineers.

CERES will be fully operative shortly after the official opening in August, 1962. In the initial stages CERES will have only two-thirds of its full complement of 200 cabinets. This will enable any consequent modifications that are required to the basic unit and will allow for any new type units which are developed to be incorporated into the present structure.

Building Layout

The main floor of the building comprises a glasshouse section divided into 15 separate units, an area for artificially lit cabinets, a number of temperature controlled darkrooms, spectrum and frostrooms, the workshop, fumigation chamber, control room and offices, and a preparation and laboratory area.

On the ground floor are located the thermal storage pond, changing rooms, offices, and some mechanical equipment. All air admitted to the phytotron passes through an electrostatic precipitator for the removal of insects, dust, spores, and for the maintenance of semi-sterile conditions those entering the building are required to change their clothing. Similarly, all equipment and plant material is passed through fumigation chambers for treatment by methyl bromide. The mechanical equipment area houses the emergency generators, pumps, and tanks for the provision of demineralized water, nutrient solution, and compressed air throughout the building. Hot water is provided from a series of solar absorber panels.

Environment Control

Each of the fifteen glasshouse sections, houses up to six cabinets. Each cabinet has a high level of individual day and night temperature and photoperiod control. Each glasshouse section has independent temperature control by means of up to 4 bench type reverse cycle refrigeration units. The glasshouse temperatures are set above that of the enclosed cabinets so that only refrigeration is required in the cabinets.

Low level environmental control, using natural light conditions, is provided in the glasshouses themselves. This type of control will be used for preliminary experiments and for less critical larger experiments.

Most of the cabinets are naturally-lit and these provide a medium level of control of the plant environment. Each naturally-lit cabinet which has 14 square feet of growing space is mounted on a self-contained scaled refrigeration unit.

View from N.E. showing transformer and mechanical equipment room on the ground floor, the main floor with the fifteen glasshouses and above them the solar water heating panels.

View of Biochemistry building from S.E.

Photoperiod control is by means of telescoped sheet metal shutters which can be raised or lowered as required. Air is circulated around the cabinet at 110 ft. per minute. The air in the cabinets is replaced with fresh air once every minute, where it is recycled once every two seconds.

The artificially-lit cabinets provide the most precise control of the environment. In these cabinets temperatures over the range from $3^{o}C$ to $45^{o}C$ can be provided to $\pm$ $0.25^{o}C$. Relatively uniform light intensity of over 4000 ft. candles can be obtained.

Artificially-lit cabinets with an extremely wide range of humidity control have been developed. They are similar to the standard artificially-lit unit but in addition provide humidity control between the extremes of 90 per cent. relative humidity up to temperatures of $30^{o}C$ and a dew point of $4.5^{o}C$ at temperatures up to $45^{o}C$.

A new data logging and alarm system has been evolved to meet operational difficulties with the fully automatic system previously proposed.

BIOCHEMISTRY LABORATORY

In December, 1961, the new biochemistry laboratory at Canberra, was occupied. In its 20,000 square feet, this building provides modern facilities for biochemical, chemical, physicochemical and biophysical research, as well as accommodating the electronics group. Special facilities include a pilot-scale laboratory with adjacent warm and cold-rooms, a laboratory specially equipped for the synthesis of radioactive compounds, rooms for the mass-spectrometer, for the analytical ultracentrifuge, for chromatography, and many other amenities.

The building houses in addition, the Agrophysics Section with its own laboratories and controlled temperature room, as well as the Divisional Common room.

X and GAMMA RAY FACILITIES

A grant from the Rockefeller Foundation of New York made possible the installation of X-ray and gamma ray facilities for the irradiation of biological material. The Australian Atomic Energy Commission and the Commonwealth X-ray and Radiation Laboratory, assisted in the design of the equipment and its protective shielding. The Cobalt 60 sources were made by the A.A.E.C. at Lucas Heights, New South Wales.

The facilities consist of a room which houses two cobalt 60 sources, one of approximately 100 curies and another of approximately 5 curies; an X-ray room housing a 250 KV 15 m.a. deep therapy X-ray generator; and a laboratory immediately adjacent to the two radiation rooms.

The main accents in the design have been flexibility and safety. Dose rates can be selected from as low as 10 r per day to as high as 22,000 r per hour for 1.3 Mev gamma rays and for X-rays dose rates up to 100,000 r per hour can be achieved for small samples.

Stringent safety precautions have been taken to protect both operating and adjacent personnel against exposure to radiation.

GRASSLAND AGRONOMY

The Grassland Agronomy Section was established in Canberra during 1961 under the leadership of Dr. F.H.W. Morley. The new group took over some studies from the former Agronomy Section and has transferred some long-term field projects from the Dickson Experiment Station, then being resumed for Canberra's urban development, to the new Ginninderra Experiment Station. Further experiments and facilities are being developed at the Station, but the development of the Section is not expected to be complete until after 1964.

The research work of this Section is planned to investigate the utilization, the biology and the improvement of grassland with special reference to sown pastures in southern Australia. The programme will consist in part of basic studies on the behaviour and intake of grazing animals and their needs. This work uses small plots, few animals, feeding pens and metabolism cages. Large-scale trials with sheep and cattle, investigating the production and management of pastures, forages or plant communities, seek to apply the more basic studies to increase the productivity of our grasslands.

CANBERRA FIELD EXPERIMENT STATIONS

The growth and development of the National Capital has had an important influence on field research conducted from the headquarters laboratories of the Division in Canberra.

The unexpectedly rapid growth of Canberra has twice forced the Division to abandon established field stations.

The initial site for field work was a section of the Military College Farm at Duntroon, which was allotted to the Division in 1930. Within a few years, breeding and genetic investigations with wheat had grown to a stage where 22,000 individually recorded progeny were raised in a single season. By 1940, some 3,000 new plants from overseas had been grown and tested by the Plant Introduction Section. The most important single advance made during the Duntroon era was the demonstration that highly productive improved pastures could be established successfully on the undeveloped natural pastures and over-cropped cereal areas on the Southern Tablelands of N.S.W. With the decision by the Government to reopen the Military College in 1939, the Division was forced to seek an alternative site.

In 1940 the Division acquired some 646 acres in the locality known as Dickson - a mile or so beyond the then suburban limits of the city. The transfer to Dickson coincided with the outbreak of World War II and although some of the earlier work was continued, the emphasis soon switched to experiments with, and in some cases actual production of specialized plant products no longer obtainable from overseas. These included opium poppies, pyrethrum, the rubber plant guayule, and vegetable seeds. The most important research of the early years was probably that concerned with potatoes, which led to an understanding of virus X and other serious diseases of potatoes.

The pasture work that had commenced so successfully at Duntroon was continued on an enlarged scale. As fertility built up, the Phalaris-subterranean clover pastures established at the new Station were able to carry increasing numbers of stock. Some fifteen years later, as many as eight dry sheep per acre could be maintained on selected areas throughout the year. Research was next directed to overcoming by conservation and other means, the seasonal fluctuations in growth which limited the use of Phalaris-sub. clover pastures for more intensive forms of livestock production. Encouraging results were obtained with special-purpose pastures based on introduced grasses.

Many varieties of Phalaris and other grasses and legumes were tested in the search for suitable plants. Some of these were collected as a result of plant exploration by officers of the Division in the Mediterranean region and North Africa. Between 1940 and 1960, about 5,000 introductions were handled at the Dickson Station.

The emphasis in plant breeding and genetics also swung to pasture plants. Early projects at Dickson included the investigation of rust resistance and dormancy and hard seededness in subterranean clover. Later breeding projects with the species included the selection of lines resistant to clover stunt virus and of other hybrids with better winter growth. The selection of "Strain 173" of barrel medic (Medicago tribuloides) was made at Dickson.

Ginninderra Experiment Station

Because of the growth of the city, the Division had again to look for a new experimental area. Development of the present field station - the Ginninderra Experiment Station commenced in 1958. The site which is located 8 miles north west of Canberra on the Barton Highway to Yass consists approximately of 2460 acres of gently undulating and lightly timbered country. There are extensive creek flats suitable for irrigation.

The environment is fairly typical of a large zone in southern New South Wales, Victoria and Tasmania. It is in many respects intermediate between the Mediterranean environment and the zone of predominant summer fainfall. The annual rainfall is about 24 in. and is distributed fairly evenly throughout the year. Summer shade temperatures very rarely exceed 100°F, frosts may occur from April to October, while low minimum temperatures persist for several winter months.

The planning of the Ginninderra site envisages approximately 750 acres for irrigation, dryland and ley farming, and about 1700 acres for the more permanent form of grazing experiment. The latter is being used for plant and animal science units of about 500 acres, each supported by appropriate maintenance centres.

The development of pasture land and agricultural facilities was speeded up to facilitate the transfer from Dickson. Improved pasture has been established on about 1000 acres; seventyfive per cent. of this is Phalaris-sub. clover, but other sowings include cocksfoot, brome, ryegrass, fescue, lucerne, red

clover and white clover. Sub-divisional fencing for pasture management and animal trials total about 38 miles, while boundary and main sub-division fences total a further 15 miles.

It is planned to provide about 200 acres of potentially irrigable land to be utilized on a rotational basis. A storage dam for about 25 million gallons has been completed, and a system of underground irrigation mains is serving the 60 acres of land already developed.

Stock at Ginninderra totals 4,700 sheep and 164 cattle. About 2000 sheep and 70 cattle are involved in the current experimental programme.

Service buildings completed include a field pasture laboratory, office block, machinery workshop, shearing shed, machinery storage sheds, hay sheds and grain silos. An animal laboratory, animal house and feed barn as part of the Grassland Agronomy research programme are currently being erected.

PASTORAL TRUST

The Australian Pastoral Research Trust has continued its assistance to the Division by providing experimental animals for its field stations.

During 1961-62 the Trust donated Aberdeen Angus cattle to the Ginninderra Station for a grazing experiment designed to investigate the effects of combined cattle and sheep grazing at various stocking rates on pasture and animal production.

This year the Trust Merino breeding flock at Canberra is being used to study the effect of clover oestrogens on oestrus, and fertility in ewes.

DICKSON PADDOCK NAMES PERPETUATED

The Downer Primary School has been built on the site of the former Dickson Experiment Station. Four of the aboriginal names by which Mr. R.M. Moore designated the various sub-divisions of the station have been retained by the School as house names, viz:

Pengarra - wide flat place
Wyeera - tree paddock
Mardango - grass paddock
Karnang - water paddock

FIELD STATION RECORD

The realization that a good deal of information of actual and potential use in agricultural research, extension and practice was remaining in the notebooks and personal records of research workers prompted the Division to initiate a new publication medium. The new periodical, which has been named The Field Station Record, will publish experimental semi-quantitative data and descriptive matter not considered appropriate for inclusion in existing journals. As the title suggests, it is anticipated that much of the material will originate at field stations, but publication will not be restricted to material from such sources.

It is intended to issue two numbers a year, the first appeared in March, 1962, and the second is expected in November.

Distribution will be to primary industry Divisions of C.S.I.R.O., regional libraries of the State Departments of Agriculture, Faculties of Agriculture and Schools of Botany of Australian Universities and to the principal libraries of each capital city in Australia.

BOOK ON GRASSES AND GRASSLANDS

Because of the importance of pastures in the Australian economy, research on grasses and pasture problems has been a major activity of the Division for the past twentyfive years. Senior officers of the Division have collaborated in preparing a book primarily designed for advanced students, research workers and teachers in botany and agriculture. The editor is Dr. C. Barnard.

The book which is shortly to be printed, will consist of a series of essays and reviews. The first half will deal with various aspects of the botany of grasses (taxonomy, distribution, form and structure, germination, analysis of growth patterns, reproduction, cytogenetics and plant breeding). The second half will deal with grasslands and pastures (nutrition, distribution, effects of grazing, erosion, and subtropical grasslands).

"FLAT" LEAF PROBLEM OF TOBACCO

A large percentage of tobacco leaf offered at last year's sales brought low prices because of its "flat" appearance. Experiments at Mareeba indicated that this condition could be induced by low levels of nitrogen nutrition and could be corrected by appropriate changes in fertilizer practice. Because of the desperate plight in which many tobacco growers had found themselves, an article outlining progress on the flat leaf investigations was published in the Australian Tobacco Journal of June 1961, even though the results were not conclusive.

As a result of this article there were requests from many farmers to try out the tentative results on individual farms. The results achieved were most rewarding. Many farmers from so-called "marginal" areas - who last year received no bids or low bids for their tobacco and some who last year were advised to abandon their farms - were successful in the current season in producing "A" quality leaf and receiving top prices for their tobacco.

The technique used is basically one of working on soil analyses during growth. This gives actual measurements of the fertilizer applied plus the fraction supplied by the soil. Thus a true indication of the nutrient status of the plant is obtained during growth. By maintaining nitrogen, phosphorus and potassium at reasonable levels the plant grows and comes to maturity under a balanced diet and at maturity it is "chemically mature". In the past, especially in many of the sandy soils where leaching occurs the plant "ripened" through starvation and was therefore "physically ripe" but "chemically immature". By checking the soil nutrient content during growth, any fall in the level of one or more nutrients can be detected and corrected by addition through the irrigation water. The aim of this exercise is to make the grower think in terms of "p.p.m. nutrients" during growth, rather than "x" pounds of N,P,K applied initially to an unknown amount in the soil.

SUCCESSFUL PLANT INTRODUCTIONS

As there is usually a considerable interval between recognition of a valuable strain and its widespread acceptance by the farming community, it is of interest to list some plants introduced by the Plant Introduction Section which have become prominent in various regions of Australia.

Western Australia:- Two introductions of cocksfoot (Dactylis glomerata) have been named and are becoming important pasture grasses. "Currie" originated in Algeria and "Neptune" in Portugal. Other strains still only known by numbers may be still more valuable. Several clovers (Trifolium cherleri, T. clypeatum, T. hirtum, and T. spumosum) show considerable promise in areas too dry for subterranean clover. Some vetches are becoming prominent grain legumes, especially an early strain of Vicia sativa.

Temperate Eastern Australia:- Grasses making a useful contribution in this area include "Brignoles" cocksfoot from France; "Demeter" fescue (a variety of Festuca arundinacea); Bromus inermis, a useful species in a genus containing some troublesome weeds; and Ronpha grass, a hybrid (introduced from South Africa) between Phalaris tuberosa and P. arundinacea. In some areas recently introduced strains of lucerne, particularly "Du Puits" and "African", are superior to Hunter River, the standard strain developed in Australia from French seed imported at a very early stage of Australian settlement.

Subtropical Eastern Australia:- Sorghum almum, a tall perennial grass from Argentina, is now planted on one million acres in north-west New South Wales and inland southern Queensland. It has greatly increased the carrying capacity in summer rainfall areas. "Katambora" Rhodes grass, a strain of Chloris gayana from Northern Rhodesia, is also prominent in this region, being superior in dry conditions to types introduced earlier. Buffel grass (Cenchrus ciliaris) is now an important pasture grass grown over much of Queensland; two of the important strains "Biloela" and "Gayndah", are derived from C.S.I.R.O. introductions originating in East Africa. Legumes whose value in building up soil fertility has been demonstrated in subtropical Queensland and include: Desmodium uncinatum, Glycine javanica, Indigofera spicata, Leucaena glauca, Lotononis bainesii, Phaseolus lathyroides and P. atropurpureus. Selection and breeding work are continuing to provide non-toxic strains of Indigofera spicata and Leucaena glauca. Glycine javanica shows great promise in inland southern Queensland, and it is hoped that numerous accessions received in the present year will increase its effective area in Australia.

FINANCE

The following table summarizes the funds received to support investigations for the twelve months ending 30th June, 1962.

Sources of funds	Amount £
Treasury Appropriation	761,900
Wool Research Trust Fund	238,100
Tobacco Industry Trust Account	88,900
Wheat Industry Trust Account	19,100
Dairy Produce Research Trust Account	6,100
Fisons-Geigy Companies Grant	18,500
Mining Research Association	6,200
Victorian Anti-Cancer Council	2,000
International Atomic Energy Agency	4,000
River Murray Commission	1,875
Sulphur Institute of Washington	1,800
Brown Rot Research Fund	2,200
Colonial Sugar Refining Co.Ltd.	500
Total:	1,151,175

The above amounts do not include capital expenditure on major building projects.

OVERSEAS VISITORS

During the year a number of scientists from overseas visited Divisional laboratories and field stations. Amongst these visitors were:

Dr. E.C. Bate-Smith, Director of the Low Temperature Research Station, Cambridge.

Dr. M. Batisse, Programme Specialist for the Arid Zone, U.N.E.S.C.O.

Professor H. Beevers, Department of Plant Physiology, University of Purdue.

Professor J.B. Biale, Department of Plant Biochemistry, University of California, Los Angeles.

Mr. K. Bridge, Technical Adviser to Amchem (U.S.A.).

Professor E.J. Britton, Department of Genetics, University of Hawaii.

Dr. R.W. Brougham, Pasture Ecologist, Grasslands Division, D.S.I.R., New Zealand.

Professor D.G. Catcheside, F.R.S., Department of Microbiology, University of Birmingham.

Professor H.D. Chapman, Department of Soils and Plant Nutrition, University of California, Riverside.

Professor V.F. Chervinsky, Senior Scientific worker, the Council of the U.S.S.R. Productive Forces Research, Academy of Sciences, Moscow.

Associate Professor J.Y. Choi, Department of Agronomy, Chunchon Agricultural College, Korea, and Mr. C.R. Rodriguez, College of Agriculture, University of the Philippines, spent twelve months with the Genetics Section to receive training in the field of mutation plant breeding. They were holders of International Atomic Energy Agency Fellowships.

Dr. A.S. Fox, Associate Professor of Biochemistry, Michigan State University, East Lansing.

Dr. M.E. Harward, Associate Professor of Soils, School of Agriculture, Oregon State University, Corvallis.

Dr. D. Heinrichs, Head of the Forage Crops Section, Canadian Department of Agriculture, Swift Current, Sask., spent nine months in the Division working on forage crop breeding.

Mr. T.C.D. Kennan, Officer-in-Charge, Pasture Research, Department of Agriculture, Salisbury, Southern Rhodesia.

Mr. J. Kotalawala, Horticultural Research Officer, Department of Agriculture, Ceylon.

Professor S. Kikuchi, Department of Applied Photochemistry and Electroengineering, University of Tokyo.

Dr. V. Korda, Director of the Department of Natural Sciences, U.N.E.S.C.O.

Professor L.T. Kurtl, Department of Agronomy, University of Illinois.

Dr. Y.T. Mao, Plant Production and Protection Division F.A.O.

Professor W.T. Penfound, Department of Ecology, University of Oklahoma.

Mr. D.V. Per Avenesian, Director of Agricultural Sciences and Deputy Director of Institute of Crops, Khazakh, S.S.R., and Mr. T. Ya Zarnbailo, a plant breeder of the same Institute.

Dr. A.F.Posnette, Head of Plant Pathology, East Malling Research Station, England.

Dr. C. Pradisth, Deputy Secretary General, Thai Research Council, Thailand.

Dr. G.A. Siwabessy, Director General of the Indonesian Institute of Atomic Energy, Djakarta. Also Mrs. Siwabessy, Deputy Head of the Institute's Raw Material Division, and former Head of the Food Technology Laboratory in Djakarta.

Professor R.H. Stoughton, formerly Professor of Horticulture at the Universities of Reading and Accra.

Dr. S.L. Tisdale, Director, Agricultural Research, Sulphur Institute, Washington D.C.

Dr. A.A. Townsend, F.R.S., Fellow of Emanuel College and Department of Applied Mathematics and Theoretical Physics, University of Cambridge.

Professor J. Tricart, University of Strassbourg, France.

Professor S.G. Wildman, Department of Botany, University of California, Los Angeles, spent nine months in the Division as a Fulbright Fellow in Physiology.

Professor P. Woldstedt, University of Bonn, Germany.

Dr. W.G. Youlden, Statistical consultant to the National Bureau of Standards, Washington D.C.

Professor F.E. Zeuner, Institute of Archaeology, University of London.

Many of the visitors gave lectures and seminar series during their visit.

OVERSEAS AWARDS AND VISITS

Mr. G. Arnold who held a Divisional Studentship at the Grassland Research Institute at Hurley, presented a paper to a Symposium on Grazing held by the British Ecological Society before returning to Canberra via the United States and New Zealand, where he visited pasture management research centres.

Dr. N.J. Barrow who held a C.S.I.R.O. Overseas Studentship at the Rothamsted Experiment Station transferred to the Western Australian group of the Division on his return to Australia. While overseas he attended the British Society of Soil Science Conference in Dublin in December, 1961.

Dr. W. Bottomley has been awarded post Doctoral Fellowships to enable him to spend twelve months with Professor T.A. Geissman, University of California, Los Angeles, and six months with Professor A.W. Galston, Botany Department, Yale University.

Dr. S.M. Bromfield has returned to Canberra after spending twelve months at the Macauley Institute for Soil Research in Aberdeen as the holder of a Royal Society and Nuffield Foundation Commonwealth bursary.

Mr. A. Costin spent a month in New Zealand at the invitation of the Tussock Grasslands and Mountain Lands Institute to advise on tussock grasslands problems.

Mr. I.A.M. Cruickshank has been invited to attend the International Symposium on Biological Control of Soil Plant Pathogens at Berkeley, California in April 1963.

Mr. D.J. David awarded a grant by the Rockefeller Foundation for travel in the United States to study new developments in spectroscopy and their application to biological research. While overseas he will work at the University of California, Berkeley, and at the Macauley Institute for Soil Research, Aberdeen. Mr. David presented a paper to the Pittsburgh Conference in analytical chemistry and applied spectroscopy.

Dr. J. Davidson, holder of a C.S.I.R.O. Overseas Studentship is studying the physiological basis of sward development and regrowth under Professor F.L. Milthorpe at Nottingham University.

Dr. J.E. Falk made a short visit to Europe in January, 1962, to discuss research on chemical and plant antifungals with Fisons Pest Control Laboratories in England and the Geigy

Corporation of Switzerland. These companies jointly are supporting research in the Biochemistry and Microbiology Sections of the Division.

Mr. C.G. Greenham is working on translocation in mistletoe with Professor A.S. Crafts at the University of California, Davis, where he holds a U.S. National Science Foundation grant.

Mr. W. Hartley during an overseas visit as Head of the Plant Introduction Section, paid extensive visits to Botanic Gardens and research institutes in various parts of Europe and Asia.

Mr. A.V. Hill visited Greece at the request of the Royal Greek Government in July and August, 1961, to give advice on the control of tobacco Blue Mould. He is now spending six months in Europe at the request of European Tobacco Organizations and C.O.R.E.S.T.A. Blue Mould spread throughout the tobacco growing countries of Europe and North Africa during the last two years virtually destroying entire crops in these countries.

Mr. A.W. Humphries is spending nine months overseas mostly working with Professor E.G. Hallsworth of the School of Agriculture, University of Nottingham.

Dr. N.P. Kefford has been awarded a Fulbright Travel Grant and a Research Associateship of the Botany Department, University of Yale. He will spend twelve months working with Professor A.W. Galston on Plant Growth regulators.

Dr. F.H.W. Morley has received an invitation to attend a Sympsoium of the I.U.B.S. on Genetics of Colonizing Species at California, in January 1963.

Mr. A. Peck is studying soil physics under Dr. E.C. Charles at the School of Agriculture, Cambridge, where he holds a Divisional Studentship.

Dr. J.R. Philip has been awarded a Nuffield Foundation Dominion Fellowship to work with Dr. G.K. Batchelor, F.R.S., in the Department of Applied Mathematics and Theoretical Physics. He also attended a Symposium on Climatic Change, held by U.N.E.S.C.O. W.M.O. in Rome, in October 1961.

Dr. J.N. Phillips, before taking up a Royal Society and Nuffield Foundation Bursary to work with Sir Eric Rideal, F.R.S., at Kings College, London, spent three months at the University of Philadelphia.

Dr. J.V. Possingham attended the Pan Pacific Science Congress at Hawaii where he presented a paper to the Symposium on Isotopes Applications in the Soil and Crop Sciences organized by F.A.O.

Dr. A.H.G.C. Rijven is spending six months working on plant nitrogen metabolism with Professor L. Yemm at the University of Bristol.

Mr. T.E. Treffry has been awarded a Hutchinson Fellowship by the University of Chicago to enable him to study for his Ph.D. with Professor L. Bogorad of the Botany Department.

Dr. P.A. Trudinger has returned after working with Professor N. Santer at Haverford College, Philadelphia and Professor Vishniac at Yale University. He attended the International Biochemical Congress in Moscow.

Dr. N.A. Walker who was awarded a C.S.I.R.O. overseas studentship to work with Professor A.L. Hodgkin at the University of Cambridge has returned to Canberra, and while overseas attended a biochemists' congress in Stockholm in July and August 1961. He also attended the Seminar on "The Agricultural and Public Health Aspects of Radioactive Contamination in Normal and Emergency Situations" held at the Hague, Netherlands in December, 1961, under the auspices of F.A.O. W.H.O., and I.A.E.A.

Dr. I. Wardlaw is on leave at Harvard University where he is spending twelve months on a post Doctorate Fellowship in Professor Thimann's department.

Dr. P.R. Whitfeld who holds a Sprague-Miller Institute Fellowship will work for a further year with Professor H. Fraenkel-Conrat in the Virus Laboratory at the University of California, Berkeley.

GENETICS AND PLANT BREEDING

This Section is concerned with the theory and practice of plant improvement through genetic adjustment. The work in progress falls into three categories:- (i) developmental and biochemical genetics; (ii) quantitative inheritance and selection theory; (iii) improvement of certain economic plants either directly by generating and selecting variability, or indirectly in the case of legumes by genetic adjustment of the symbiont bacteria which fixes atmospheric nitrogen.

In the first of these phases, basic work is being done on the biochemistry and the nature of the hereditary material. The origin of new genetic function is being investigated using bacteria as the experimental organism. Work is in progress on the synthesis and replication of DNA and RNA. These studies attempt to define the nature of the gene and its mode of action.

The other two phases of work provide an integrated pattern for the manipulation of characteristics with complex inheritance. The first aspect of this pattern involves the production of genetic variation by mutagens and the study of the principles and usefulness of induced mutation in plant improvement. The second aspect concerns the mathematical treatment of quantitative inheritance and selection theory. Theoretical investigations are put to test in experiments using suitable, rapidly reproducing organisms (Drosophila and Arabidopsis).

Finally, those concepts which are proven suitable, are applied in plant improvement programmes. Plant breeding work with subterranean clover, Phalaris tuberosa, lucerne and tobacco is in progress.

BIOCHEMICAL GENETICS

Experiments in the evolution of genes

J.B. Langridge

The evolution of the higher taxonomic groups requires the origin of new genes and new enzymes, as well as quantitative changes in the level of gene action and losses of genes by mutation. At present there is no knowledge as to how new genes arise, largely because bona fide examples of mutation involving

qualitative changes in gene function have not been found.

Experiments designed to provide information on this question, are being made with the glycosidases of Escherichia coli. The aim is to alter by mutation the specificity and kinetic constants of some of these glycoside-splitting enzymes. Theoretically, the frequency of mutational change in specificity is expected to depend upon the stereochemical difference between the natural glycoside and the one to which mutation is required. Preliminary experiments, which support this expectation, are described in last year's Annual Report.

Further work has been concerned with the mechanism whereby the bacteria acquire the ability to split lactobionic acid (galactose-β-gluconic acid). Wild-type bacteria are unable to hydrolyze this compound at a measurable rate, but mutations may be induced to this ability with a frequency of about 3.4×10^{-11}. Comparative kinetic studies of mutant and wild-type enzymes have shown that the affinity of the enzyme of the mutant for all β-galactosides has been reduced, although the maximum velocity is in each case greatly increased. It appears that the ease with which the enzyme can hydrolyze a glycosidic bond is largely independent of the fit of that enzyme to the substrate. Thus, in the example studied, the mutational event has so altered the structure of the enzyme protein that it is now more efficient in cleaving the bond joining galactose with gluconic acid (as shown by the maximum velocities). Although this structural alteration has been obtained at the expense of reducing the closeness of fit of enzyme and substrate (as shown by the affinity constants), the net result is an ability to utilize a compound for growth which was previously unavailable. In this example, there has been no change in enzyme specificity.

Investigation of 5-Bromodeoxyuridine on the production of Vaccinia virus

C.I. Davern (in association with K. Easterbrook, Microbiology Dept., Australian National University)

Further progress has been made in elucidating the nature of the 5-bromodeoxyuridine (BUDR) inhibition of infective vaccinia production. A density gradient analysis of the DNA extracted from purified vaccinia from a BUDR inhibited culture, demonstrated the incorporation of this thymine analogue into the DNA. Furthermore the molecular weight of this bromo-uracil substituted DNA appeared to be considerably less than that of normal vaccinia DNA, suggesting either some fragmentation of the DNA as

a result of bromo-uracil incorporation, or an increase in the fragility of DNA such that it fragments on isolation.

Electron micrographs taken by Professor H. Mercer, of the appearance of vaccinia particles in sections of infected cells prepared by Easterbrook showed vaccinia particles formed in BUDR treated cells to be highly irregular in their shape, size and disposition of their enclosing membrane. Such irregularity is unlikely to be due to bromo-uracil substitution in the DNA per se, for this analogue is so similar to thymine in its shape and size. However, if such DNA fragments, the enclosing of smaller amounts of DNA in the protein coat may proceed abnormally, and hence lead to the maturation of particles which are defective in invading host cells.

The isolation and characterization of an RNA bacteriophage

C.I. Davern

In comparison with the information gathered on the genetics of organisms whose hereditary properties are based on DNA there is virtually no information available on the genetics of RNA organisms. Nothing is known about the mechanics of replication of RNA in the course of multiplication of viruses which possess this molecule as a genetic template.

This gap in our knowledge of RNA molecular biology and genetics stems from the technical unsuitability, in various attributes of the RNA viruses which have been subjected to close study in the past. There is therefore, a real need for a virus which possesses the attributes of the DNA bacteriophage, such as high efficiency of plating, ease of purification, stability, good genetic markers, simplicity and cheapness of culture. Recently in U.S.A., an RNA bacteriophage was isolated from sewage.

A direct screening method for getting RNA bacteriophage from sewage was immediately developed here. The DNA synthesis inhibition 5-fluorodesoxyuridine (5-FUDR) was used to suppress the multiplication of DNA bacteriophage which predominate. Sewage samples from the Canberra sewage farm were inoculated onto two cultures of both male and female bacteria (Escherichia coli) in the presence of 5-FUDR. Bacteriophage were found in all cultures. However, only those cultures isolated from male cells proved to be RNA phage. The identification of the nucleic acid as RNA was established on phenol extracted nucleic acid from highly purified phage, using enzymatic, direct chemical assay,

and buoyant density analysis.

Physical studies on the purified bacteriophage demonstrated it to be a very small spherical bacteriophage (about 300Å in diameter), with a sedimentation constant of 79.5 S, and a buoyant density in CsCl of 1.42 gm/cc. The ratio of nucleic acid to infective particles indicated that this RNA bacteriophage possesses a RNA molecule MW of 1.5 - 2 x 10^6, and is thus similar in this respect to all other RNA containing viruses so far examined.

Currently studies are being made on the fate of the parental phage RNA molecule using ^{32}P labelled phage. These "transfer" studies may throw light on the mode of replication of the RNA molecule.

QUANTITATIVE INHERITANCE AND SELECTION THEORY

Plant breeding theory

B. Griffing

The purpose of these studies was to generalize selection theory to develop a more realistic genetic model which includes linkage and epistasis. The programme involved a systematic reanalysis of important selection designs in terms of the more complete genetic model.

One of the first problems was to consider the effect of chromosome configuration (such as the position effect due to differences in cis- and trans- configurations) in the gene model. Configuration effects were defined, expectations of covariances among relatives derived, the bias in variance component estimation determined, and the situations in which these effects could be important were outlined.

The theory of general combining ability selection has been explored in some detail. This form of selection, which is of special importance to plant breeding, involves the evaluation of an individual on the basis of the performance of its progeny.

A study has been completed in which various combinations of individual and general combining ability selection are made. These combinations result from applying one of the following conditions to each sex, (i) no selection; (ii) individual selection; and (iii) general combining ability selection. It was found that

selection in each sex contributes independently to the genetic advance, and that in the most general genetic situation, the immediate response to selection is formulated in terms of covariances among relatives; the particular covariance depending on the particular form of selection.

A study is now being completed of an entire system of related general combining ability selection schemes, which involve one or two base populations. Among others, the schemes include the commonly used recurrent selection method and the more controversial recurrent reciprocal selection method. The objectives are, (i) to develop, for each selection scheme, the prediction formulae for genetic improvement due to repeated cycles of selection, and (ii) to compare the maximum potentials of the various selection methods.

Estimation of genetic parameters in Phalaris

B.D.H. Latter

The programme designed to give a detailed description of the nature of the genetic variation present in the Australian commercial population of Phalaris tuberosa for flowering date, seed weight and measures of seedling vigour is now almost completed. On the experimental side, the only observations not yet taken are those of seedling characteristics in full-sib family groups produced by controlled pair-crossing under glasshouse conditions during November-December 1961. As regards flowering time and seed weight, the analyses are now almost finalized and have given a useful picture of the composition and behaviour of the population; the genetical principles involved in the analysis have not previously been worked out in detail, and no experimental analysis has been published which adequately explores this type of situation.

It is proposed to publish the results of the investigation in three papers: The first is to be devoted to an extension of the theory of quantitative genetics in open-pollinated progenies; the second describes the experimental work with flowering time and seed weight; and a third paper will deal with the extremely complex inheritance of seedling vigour and its components.

The conclusions have some relevance to the section's Phalaris breeding programme involving a broad array of introductions of the species topcrossed to the Australian commercial population. All three characters are under selection (in

McWilliam's and Oram's programmes) and the parental introductions show well defined associations in the means for the characters. Those introductions which are early maturing tend to have large seeds and high seedling vigour, and the converse is true of those which mature later. From a breeding viewpoint, one is concerned to know whether the observed associations are likely to be readily broken, i.e. whether their association is purely ecotypic, or whether physiological relationships will lead to permanent genetic correlations.

The analysis of an established population in linkage equilibrium is therefore of great value in furthering an understanding of these relationships. In addition, a collaborative study with McWilliam and Oram using their present breeding population has been initiated, and the behaviour of the three characters in this wider context will provide further information of value in the planning of the breeding procedures.

Genetic and developmental homeostasis in Drosophila

B.D.H. Latter

In an earlier study it was demonstrated that the highly canalized developmental processes leading to the formation of a pattern of macrochaetae on the scutellum in Drosophila melanogaster are such that disturbance of the genetic equilibrium in a wild-type population leads to a rapid reduction in reproductive fitness, and to pronounced homeostatic behaviour on relaxation of selection. The nature of these effects is under more intensive study in experiments designed to separate homeostatic behaviour due to natural selection from that due to epistatic interactions between loci. A detailed study of the genetic properties of a population stabilized by natural selection at a new level of expression of the character is expected to throw further light on the evolution of canalized genetic systems.

Studies of plant competition using Arabidopsis thaliana

J.B. Griffing and J.B. Langridge

One of the most promising plant breeding methods, especially applicable in self-fertilized crops, is the use of simple and complex genotypic mixtures. A programme has been started with Arabidopsis thaliana with the objective of investigating the principles underlying competition among genotypes.

This involves defining "competitive" parameters, and then using these parameters to describe the competitive aspects of pure and mixed populations.

A second objective is to examine the use of mixtures of genotypes to maintain the maximum average growth rate over an array of different environments. The hypothesis under test is that a range of genotypes has a potential greater than a single homozygous genotype. The competitive aspects of pure stands and mixtures are simulated by planting several seeds per test tube (where plants are grown in aseptic culture). So far only preliminary experiments have been performed and these indicate that marked differences in competitive ability do occur in different races of Arabidopsis.

A genetic and molecular explanation for heterosis

J.B. Langridge

An explanation for heterosis in organisms whose internal temperature adjusts to the environmental temperature has been published in the "American Naturalist". Several experts in the field of heterosis have mentioned a weakness in the experimental data supporting the explanation, which may prevent its general acceptance. The objection is that it has not been clearly proved that heterosis is manifest only under high temperature stress and not under other stress conditions.

A series of experiments, therefore, has been made in which heterosis is measured under conditions of high ionic concentration and high osmotic pressure in the medium, in the presence of inhibitors such as sulphanilamide and formamide, and at low inorganic nutrient levels. These experiments are not yet completed, but so far no significant amount of heterosis has been obtained with any stress other than high temperature.

GENETICS AND BREEDING OF ECONOMIC PLANTS

PASTURE PLANT IMPROVEMENT IN THE RIVERINA

Strain trials

R.N. Oram

Data obtained in 1961 support the earlier hypothesis that wheat belt pastures would be more productive if the annual grasses were replaced by a perennial.

In a grazing trial the perennial Phalaris tuberosa is proving superior to annual Wimmera rye-grass when grown in association with subterranean clover. This is due to greater summer productivity and reduced weed invasion on the Phalaris pastures. In plot trials certain Algerian and Moroccan strains of P. tuberosa were again more productive than commercial P. tuberosa or cocksfoot during the autumn and winter. However, cocksfoot strains were superior in early summer.

Trials involving 30 strains and species of perennial grasses have been established with subterranean clover for a comparison of yield and persistence. The most productive of these are being included in a co-operative testing programme at seven sites throughout the Riverina. The trial includes species and strains of Phalaris, Dactylis, Hordeum, Lolium and Ehrharta.

Further trials of subterranean clover have shown that the new variety "Howard" is superior to other strains in seedling density and is as productive as the highest yielding strains.

Several summer growing perennials were assessed for survival and summer fodder production. The productivity of Sorghum almum, Hyparrhenia hirta and green panic was equal to lucerne. Hairy Peruvian lucerne produced 20 per cent. more dry matter than Hunter River.

Breeding objectives in P. tuberosa

R.N. Oram

Optimal heading date and growth habit inter alia in P. tuberosa for Riverina pasture are not known. Attempts to determine the ideal levels are being made by two different methods. Firstly, a highly variable F_2 population is being exposed to natural selection in grazed swards. The highly productive survivors will be extracted, recombined and subjected to a further cycle of selection. Examination of the most productive survivors should reveal the optimal combination of characters. Secondly, paired populations differing only in heading date and growth habit are being selected. When these are available direct comparisons will be made.

Breeding short-term perennial grasses

R.N. Oram and K. Hoen

Phalaris:- Productive plants have been selected from interstrain hybrid Phalaris coerulescens swards and recombined

for further selection.

Phalaris tuberosa has been crossed with the annual species P. minor and P. canariensis with the object of developing perennials with the seedling characteristics and early vigour of the annuals. F_1's, allopolyploids and backcrosses are being examined and selected.

Hordeum bulbosum:- In an effort to eliminate the undesirable awn characteristics and to improve this potentially valuable species progeny from irradiated pollen and interstrain crosses were examined. Fifty thousand X-1 plants were screened for useful dominant mutants. No suitable mutants were found. Mass selection from 20 F_2 families is being attempted.

PHALARIS

Selection

J.R. McWilliam, R.N. Oram and K. Hoen

Work has been continued at Canberra and Wagga on the selection and breeding of P. tuberosa to combine the best features of the well adapted Australian commercial strain with those of selected ecotypes from the Mediterranean region. This approach is based on a truncation selection programme using independent culling levels with the main emphasis on seedling vigour, flowering time, and autumn and winter growth. Two cycles of single plant selection have been completed and the next phase of the programme, involving the large scale evaluation of progenies under sward conditions, is in progress. A comparison of the most promising selections with respect to the commercial controls after two cycles of selection indicates a significant increase in seedling vigour and autumn and winter growth.

An experiment is in progress to provide genetic information including estimates of heritability and genetic correlations for those traits under selection. This information, coupled with physiological studies using controlled environment facilities, should help to increase the efficiency of selection and enable predictions to be made of the potential improvement possible.

Two other characters of potential value in Phalaris tuberosa have been studied; (i) a long vernalization requirement leading to non-flowering in spring sown pastures; and (ii) retention of mature seed in the panicle. Variation exists for

both characters and the genetic evidence suggests that rapid progress should be possible with selection.

Seed retention

J.R. McWilliam

The loss of seed from the maturing inflorescence of P. tuberosa constitutes a major problem in commercial harvesting of seed. An investigation of the plant characters influencing this process has been undertaken to provide a basis for selecting for increased seed retention. In a range of P. tuberosa ecotypes studied, the seed retained per inflorescence, seven weeks after flowering (the optimum time for harvesting), varied from 30-80 per cent. of the mature seed formed. The highest percentage of seed was retained by plants from the variety "El gaucho" which possesses relatively short inflexible panicles with densely packed spikelets. These features together with the dimensions of the seed and the nature and stiffness of the sterile glumes are strongly associated with the ability to retain seed. The relative amounts of opaline silica in the glumes and inflorescence structure is also being investigated to determine if this feature is influencing the retention of seed. An experiment based on a parent progeny regression analysis is in progress to obtain an estimate of the heritability of seed retention in P. tuberosa.

Interspecific hybridization

J.R. McWilliam

Crosses between P. tuberosa and P. arundinacea (6x) have been successful, and a wide range of F_1 families have been produced. The main virtues of this hybrid lie in its wide range of adaptation and long growing season, particularly during the summer, when P. tuberosa is normally dormant. In this respect the hybrid combines the seasonal growth characteristics of both parents, and shows heterosis for yield during the autumn and winter.

The sterility of the F_1 hybrid has been overcome by doubling the chromosome complement with colchicine, and a range of allopolyploids has been produced. Breeding at the allopolyploid level, involving hybridization and selection for increased fertility, stability, and desirable agronomic features is in progress. The possibility of greater adaptation to extreme environments is being investigated both in CERES and over a range of

contrasting environments in the field.

A technique for producing large quantities of F_1 hybrid seed under field conditions has been developed. Highly cross-compatible and self-sterile genotypes of both species, selected for superior specific combining ability and similar flowering times, were multiplied clonally and interplanted in isolation. The incorporation of a single dominant gene marker (red root tip) in the P. arundinacea parent, permits a rapid estimate of the hybridity of the seed harvested. This technique offers good scope for the commercial exploitation of this promising hybrid.

Selection and testing of the hybrid and fertile derivatives, both under experimental conditions and in more extensive grazing trials, is in progress at a number of centres throughout New South Wales.

Successful hybrids have been obtained for the first time between P. tuberosa and P. coerulescens using irradiated pollen. P. coerulescens, a diploid member of the genus is a potentially valuable species because of its early vigour and palatability. Testing of the hybrids and the restoration of fertility is in progress.

Cytogenetics

J.R. McWilliam and R.N. Oram

Cytological studies of interspecific hybrids in the genus Phalaris are continuing. The isolation of a haploid plant of P. tuberosa and the success of hybridization between allotetraploid P. tuberosa and two diploid species, P. coerulescens ($2n = 14$) and P. canariensis ($2n = 12$) has provided further valuable material for this study. A genome analysis has been undertaken to gain further information on the systematic and phylogenetic relationships in the genus. This information is also valuable for indicating further avenues for hybridization.

SUBTERRANEAN CLOVER

"Subspeciation, natural selection and selection for yield" which have in the past been reported under Genetics are now reported under Grassland Agronomy.

Resistance to subterranean clover stunt virus

J.W. Peak

The resistance status of a large range of introductions from the Mediterranean region has been assessed by field testing. All lines showing resistance are being retested under conditions of multiple replication and artificial inoculation in the glasshouse.

The inheritance of resistance from Tallarook, Hills Small, Bass B and Howard is being studied in F_1's and F_2's of crosses with a range of susceptible commercial strains.

LUCERNE

Inheritance and breeding for creeping root

H. Daday

The occurrence of creeping ability in certain varieties of lucerne is the result of unusual meristematic activity in the phellogen, leading to the development of primordial domes and later to aerial shoots on the roots. Investigations have shown that the initiation and expression of creeping root are determined by both genetical and environmental factors.

The inheritance of creeping root was studied on F_3 spaced plants of Rambler crossed with Hairy Peruvian, African and Hunter River strains. The analysis showed multiple gene control with both additive and non-additive gene effects contributing to the genotypic variances of the creeping root character.

Physiological investigations indicate that the expression of creeping root is stimulated by short day and low temperature treatments. The F_3's were less dependent on this environmental stimulus for expression than was the variety Rambler.

Selection and recombination of the available creepers produced F_3 families with good forage yield and an average of 41 per cent. creeping rooted plants with a range between families from 0-81 per cent. creepers.

The genotypic correlation coefficients between creeping and summer forage scores, and creeping and winter forage scores

were -0.09 and +0.59 respectively; that between summer and winter forage scores was +0.48. Thus an association between creeping root and plant vigour is possible.

Heterosis

H. Daday

The partitioning of the components of genetical variances for forage production disclosed highly significant additive and non-additive gene effects in lucerne. Selected F_1's were established at two different localities in New South Wales under sward conditions. The yield of the F_1's was significantly greater than that of the parental varieties at both localities. This heterosis was expressed at both high and low temperature, which suggests that the manifestation of heterosis was temperature independent, in contrast to the temperature dependent heterosis reported for Arabidopsis and Drosophila.

Genotype x environment interaction

H. Daday

Several varieties were grown both under Tableland (Canberra, Armidale) and Coastal (Milton) conditions for three years. The performance of genotypes was markedly different in the two environments. This low genotype-environment correlation suggests that markedly different genes become responsible for yield in different environments. This result underlines the importance of selecting a genotype for each particular environment.

Yield recombination

H. Daday

The possibility of combining summer and winter yielding abilities of lucerne varieties was investigated. Selected varieties were intercrossed and selections made in the F_1 and F_2 generations. Several lines performed well in both summer and winter and gave significantly higher yields than Hunter River under Canberra field conditions.

Several varieties and F_2 lines of lucerne were grown under different temperature treatments. The growth rates of all lucerne varieties were significantly influenced by the temperature treatments, while the F_2 lines showed very little growth

rate fluctuation under various temperature conditions.

WHITE CLOVER

Mechanism of natural selection

H. Daday

The effect of balanced and non-balanced natural selection on the formation of gene frequency clines has been previously published. Further work has been aimed at establishing the physiological significance of the Ac Li gene interactions.

When the Ac Li phenotype was exposed to various temperature treatments there was an active hydrolysis of the cyano genetic glucoside at low and high temperatures, but not in the intermediate temperature range. The hydrolyzing enzyme was found to be irreversibly activated by low temperature, causing complete inhibition of the cell's metabolism. On the other hand, the activation of the hydrolyzing enzyme was reversible at moderately high temperatures and irreversible with still higher temperature treatment. The chemical product of hydrolysis caused inhibition of respiration; its effect on photosynthesis is being investigated. The enhanced activity of the enzyme at low temperature may explain the disadvantage of the genes under the particular climatic conditions which govern the gene frequency clines described previously.

Remarkable differences in adaptibility to alpine and coastal environments were shown by different genotypes. The genotype Ac Li was well adapted to the warm temperatures of the coastal environments while ac li was well adapted to the low temperature of the alpine environments.

TOBACCO

Resistance to blue mould

D.C. Wark

Plant breeding and genetical studies of resistance to blue mould (Peronospora tabacina Adam.) are in progress. The objective of the breeding programme is to develop tobacco varieties resistant to blue mould and to furnish highly resistant material to tobacco breeders. Testing and selection for high

level resistance is done in the greenhouses at Canberra with some field testing at the Victorian Tobacco Research Station, Myrtleford and at Mareeba, Queensland. Selected lines are also used as parent lines at the Tobacco Research Institute, Mareeba. Breeding lines have also been sent to several European countries and to the U.S.A. for use by plant breeders in these countries.

Breeding material under test includes: (i) backcross lines resembling cultivated tobacco in appearance, with resistance derived from Nicotiana debneyi, N. goodspeedii and N. knightiana; (ii) Amphidiploids and early backcross lines from N. exiqua, N. suaveolens, N. amplexicaulis and N. velutina; (iii) local races of Nicotiana species for possible new types of resistance; (iv) the progeny of pollen grains treated with ionizing radiations in an endeavour to obtain resistant mutants.

Three advanced resistant lines have been tested by the Departments of Agriculture in Queensland, New South Wales and Victoria. These lines combined appreciable field resistance to blue mould with good agronomic characters, but the leaf when cured, was somewhat inferior to that from susceptible commercial varieties. Two of these lines, with resistance derived from N. goodspeedii, whilst resistant to leaf infection, developed heavy stem infection. This indicates a need for routine testing of all leaf-resistant lines for susceptibility to stem infection.

About thirty lines, with resistance derived from N. debneyi, N. goodspeedii or N. knightiana are approaching commercial types but require further backcrossing and selection. Some segregants combine high field resistance, with good Virginia Gold type leaf, and the "tall" character introduced from a natural mutant found in a commercial tobacco crop at Myrtleford. Further field trials, and especially curing tests, will be necessary before it can be ascertained whether any of these lines will be suitable for commercial production.

Resistance, no matter what its source, has been inherited as a single dominant gene in the field, but with a deficiency of resistant plants (varying in amount from year to year) at Myrtleford, and in an irregular manner not suggestive of any simple genetic ratio in greenhouse tests at Canberra. Different ecotypes of P. tabacina have given different ratios of susceptible to resistant plants in greenhouse tests.

During the year, 25,000 plants arising from ultra-violet treated pollen were tested for dominant resistance to blue mould without finding any evidence of induced resistance.

DEVELOPMENTAL GENETICS

Genetics of flower morphogenesis in wheat

O.H. Frankel, A. Munday and S. Lewis

Basal sterility is a condition in wheat, so far only found in speltoid mutants, in which flower formation in one or more basal flowers of some or all spikelets is impaired. The degree of flower abnormality varies from loss or reduction of the anterior stamen to complete absence of any flower parts. The sterility pattern is rigid within spikelets, the next higher flower never being more affected than the lower one, so that only if the lowest is affected may the second one be affected and so on. Two kinds of genetic systems responsible for flower formation are postulated. The first consists of "canalization factors", the second of a number of polygenes acting only in the absence of the former.

The first canalization factor which is common to all bread wheats (T. vulgare) causes the first (lowest) flower, hence all subsequent ones, to be normal. The second canalization factor causes the second (and further) flowers to be normal.

A series of genotypes differing in their extent of flower abnormality are being studied to gain an understanding of the hereditary component of morphogenesis in flower formation and also to uncover the evolution of flower morphogenesis.

Several new approaches are being used in the analysis of this complex situation. Firstly, a large number of interspecific crosses have been made, some of which, according to our assumptions, will possess canalization factors and others will not. Secondly, a series of crosses with the monosomic series of bread wheats to locate the second canalization factor in a chromosome has been completed; the first is indubitably in the chromosome IX. Thirdly, the line selections have been continued with a view to analyzing the secondary system and its interactions with the second canalization factor. Fourthly, x-ray mutants are being studied. The families have not yet been finally analyzed, but it is clearly likely that some of the x-ray speltoid mutants possess yet another canalization factor which would cause completely normal flower formation - as complete as in T. vulgare - in the absence of the first flower canalization factor which is carried by vulgare.

RADIATION GENETICS

INDUCED QUANTITATIVELY INHERITED VARIATION

Flowering time in subterranean clover

R.D. Brock

A single treatment with x-rays and neutrons generated variation in flowering time in the late flowering commercial variety, Tallarook, which was comparable in magnitude to that generated in F_2's of intervarietal crosses. Selection for early and late flowering time resulted in a symmetrical response to selection suggesting that this technique may offer an attractive alternative to wide hybridization as a means of generating variability in well adapted self-fertilizing varieties.

A second cycle of radiation and selection has now been applied to both early and late flowering mutants selected from the first cycle of treatment and the extent of the additional induced variation measured. The second burst of radiation generated additional variability in both lines, however, the further progress that could be achieved by selection from this freshly induced variability was only approximately 20 per cent. of that achieved in the first cycle. No progress could be made by selection without additional radiation treatment indicating that no residual variation which could be utilized by selection remained in either of the mutant lines by the M-4 generation.

Flowering time and growth rate in Arabidopsis

R.D. Brock, J.Y. Choi and C.R. Rodriguez

The analysis of flowering time variation in an M-2 population of Arabidopsis at optimal growing conditions showed no change in the mean of the irradiated populations, a symmetrical distribution about the mean, but a threefold increase of total variance in the M-2 over the C-2.

For plant weight, again there was no change in the mean. The C-2 distribution was symmetrical, but the M-2 distribution was skewed towards low plant weight. Total variation in the M-2 was 70 per cent. greater than in the C-2.

Covariance analysis indicated a genetic correlation of only 0.07 indicating that the two characters were independent

under these optimal growing conditions.

However, when grown under continuous light and at high temperature, sub-optimal condition, there was a definite correlation between reduced plant weight and late flowering.

Induced "mutations" in vegetatively propagated species

R.D. Brock and R.R. Rochford

Preliminary experiments have been commenced with apples, daffodils and tulips to assess the potential value of induced "mutations" in vegetatively propagated species.

Root knot nematode resistance in tomatoes

R.D. Brock and J.E. Giles (Commonwealth Research Station, Merbein)

The following screening has so far been made for mutagen-induced resistance to root knot nematode: (i) for dominant mutations; progeny from 17,750 pollen grains treated with ultra-violet light and x-rays; (ii) for recessive mutations; progeny from 2,279 pollen grains treated with ultra-violet light and x-rays, and 2,265 seeds treated with x- and gamma-rays. As yet, no mutants resistant to the highly virulent "B" strain of the nematode have been discovered.

Mutation rate - dose rate studies

R.D. Brock and I.R. Franklin

Using tester stocks of tomatoes containing three seedling marker genes, mutation rates induced by acute and chronic gamma radiation are being measured. Dose rates are 25.56 rads per hour for the chronic radiation and 10,340 rads per hour for the acute radiation.

Radiation sensitivity

R.D. Brock and C.R. Rodriguez

Marked differences in sensitivity to gamma radiation, as measured by growth rate and plant weight of M-1 plants have been found between strains of Arabidopsis. A survey of all available

strains is in progress. Sensivitity differences between fresh and aged seeds of the strain Estland have also been demonstrated.

Rhizobial genetics

A.E. Schwinghamer

The current project in rhizobial genetics represents a continuation of a research programme initiated at Brookhaven National Laboratory (Upton, New York) in 1958, and replaces a similar programme initiated in 1960 at Canberra by the late Dr. R.E. Wright.

Objectives of the project may be broadly listed as follows:- (i) to determine which mechanisms of genetic change or transfer occur in nature or may be experimentally exploited in Rhizobium; (ii) to employ available mechanisms in attempts to extend the host range and nitrogen-fixing efficiency of the rhizobial bacteria by bridging interspecific barriers within Rhizobium or, more remotely, intergeneric barriers between Rhizobium and closely related genera like Agrobacterium; (iii) to derive basic information concerning the inheritance of the symbiotic characters and the evolution of the host-bacterial relationship.

Research on Rhizobium at Brookhaven Laboratory included development of a synthetic medium and modification of nodulation techniques, radiation (ultra-violet light, x-rays, neutrons) sensitivity determinations for several strains, marking of strains with antibiotic resistance lysogenicity studies and demonstration of radiation-induced mutation for gain in interspecific host range.

Current research involves lysogenicity studies with strains of R. leguminosarum, R. phaseoli, and R. trifolii and a study of some interstrain "antagonism" phenomena encountered in the lysogeny experiments. Attempts will be made to demonstrate the occurrence of phage-mediated transduction, as yet not reported for Rhizobium.

Similarly, experiments will be designed to probe for the occurrence of sexual recombination in Rhizobium. Recombination would provide a most useful genetic tool for simultaneous transfer of both nodulation and nitrogen fixation especially since the latter character is difficult to evaluate on a single nodule basis.

DNA-mediated transformation, already employed successfully in several species of rhizobia by Balassa and co-workers in Hungary, provides a useful alternative method - particularly for bridging "wider" interspecific gaps where phage or mating specificities may exclude the use of transduction or recombination.

PUBLICATIONS

Brock, R.D., and Brown, J.A.M. (1961). - Cytotaxonomy of Australian Danthonia. Aust. J. Bot. 9: 62-91.

Brock, R.D., and Latter, B.D.H. (1961). - Radiation-induced quantitative variation in subterranean clover. In "Radiobiology". (Ed. P.L.T. Ilbery), (Butterworths, London). pp. 205-15.

Brock, R.D. (1960). - Radiation and plant improvement in Australia. Conference on the Technological Uses of Radiation, Sydney. (Melb. Univ. Press). pp. 71-75.

Daday, H., Mottershead, B.E., and Rogers, V.E. (1961). - Performance and interaction in varieties of lucerne (Medicago sativa L.). Aust. J. Exp. Agric. Anim. Husb. 1: 67-72.

Daday, H. (1962). - Breeding for creeping root in lucerne (Medicago sativa L.). I. The initial response to selection. Aust. J. Agric. Res. 13: (In press).

Frankel, O.H., and Munday, A.M. (1962). - The evolution of wheat. In "The Evolution of Living Organisms", Roy. Soc. Vic., Darwin Centenary Symposium, Melbourne 1959. pp. 173-80.

Griffing, J.B. (1961). - Accommodation of gene-chromosome configuration effects in quantitative inheritance and selection theory. Aust. J. Biol. Sci. 14: 402-14.

Griffing, J.B. (1962). - Consequences of truncation selection based on combinations of individual performance and general combining ability. Aust. J. Biol. Sci. 15: 333-51.

Griffing, J.B., and Langridge, J.B. (1962). - Phenotypic stability of growth in the self-fertilized species Arabidopsis thaliana. Proc. Symp. on Statistical Genetics and Plant Breeding, 1961. (Raleigh, N.C.). (In press).

Langridge, J.B. (1962). - A genetic and molecular basis for heterosis in Arabidopsis and Drosophila. Amer. Nat. 96: 5-27.

Latter, B.D.H. (1962). - Changes in reproductive fitness under artificial selection. In "The Evolution of Living Organisms". (Ed. G. Leeper). (Melb. Univ. Press). pp. 191-202.

Latter, B.D.H., and Robertson, A. (1962). - The effects of inbreeding and artificial selection on reproductive fitness. Genet. Res. Camb. 3: 110-38.

Latter, B.D.H. (1962). - Genetic homeostasis and the theory of canalization. Proc. Symp. on Statistical Genetics and Plant Breeding 1961. (Raleigh, N.C.). (In press).

McWilliam, J.R. (1961). - Selection for agronomic characters in Phalaris tuberosa L. Cereal and Pasture Plant Breeders Conf. 1961. pp. 36-1 36-10. (Australia).

McWilliam, J.R., and Neal-Smith, C.A. (1962). - Tetraploid and hexaploid chromosome races of Phalaris arundinacea L. Aust. J. Agric. Res. 13: 1-9.

McWilliam, J.R. (1962). - Interspecific hybridization in Phalaris hybrids between Phalaris tuberosa and the hexaploid race of Phalaris arundinacea. Aust. J. Agric. Res. (In press).

Morley, F.H.W., Davern, C.I., Rogers, V.E., and Peak, J.W. (1962). Natural selection among strains of Trifolium subterraneum. In "The Evolution of Living Organisms". (Ed. G. Leeper). (Melb. Univ. Press). pp. 181-90.

Oram, R.N. (1961). - The requirements and breeding of grasses for the wheat belt. Cereal and Pasture Plant Breeders Conf. 1961. pp. 35-1 35-7. (Australia).

Wark, D.C. (1961). - Frenching in Nicotiana species. J. Aust. Inst. Agric. Sci. 27: 160-2.

PLANT INTRODUCTION

The activities of the Plant Introduction Section are concerned with the procurement and preliminary evaluation of wild and cultivated economic plants on behalf of C.S.I.R.O. officers and collaborating institutions throughout Australia. This involves exchanges of plant material with countries of similar climate in all parts of the world, and the organization and conduct of plant exploration missions to search for species and varieties of plants of potential value to Australian agriculture. In this work, special regard is given to plant quarantine, to minimise the risk of introduction of weeds, insect pests and diseases.

Because of the importance of pastures in the Australian economy, the introduction of pasture and forage plants forms a major activity of the Section. New introductions are grown initially in quarantine nurseries, and are subsequently tested more extensively in regions to which they are adapted, such tests usually being conducted in collaboration with the several State Departments of Agriculture.

A knowledge of plant geography and the factors influencing plant distribution forms an essential basis for plant introduction, and both experimental and non-experimental studies are in progress designed to provide a better understanding of these subjects.

SEED EXCHANGE

International Exchange

W. Hartley and Mrs. C. Slater

Overseas exchange activities continued at a high level during the year. No overseas seed collecting was done by members of the Section, but many samples, especially of legumes were forwarded from most of the major countries of South-East Asia by an Australian Agronomist working under the auspices of S.E.A.T.O. Nursery testing of these accessions is proceeding in Queensland.

Distribution of a new Seed Exchange List has led to very numerous requests for seed from all parts of the world. These requests are being met as far as possible, but stocks of intro-

duced seeds have not always been sufficient to meet the demands. Collection of native seeds has continued mainly in the Canberra area, and useful supplies have also been received from collaborators from various parts of Australia.

Annotated Quarterly Lists of Introductions were distributed to interested persons throughout Australia, particularly in the State Departments of Agriculture.

QUARANTINE

Examination and Control

Miss D. Johns

Of the 2,383 introductions examined for weed seeds, disease and insect pests during the year, 1047 were received as a result of the visit of Dr. D. Parbery to various South-Eastern Asian countries during the tenure of a S.E.A.T.O. fellowship.

In addition, 2014 seed samples sent to various countries overseas and 640 forwarded to meet requests emanating from within Australia were similarly examined prior to despatch.

The introduction of seeds of legume species in particular presents special hazards because of the danger of their bringing with them certain specific diseases such as Bacterial Wilt in lucerne and various viruses as yet unknown in Australia.

The Plant Introduction Section has assumed special responsibility for the examination of such incoming seed and several hundred new introductions have been grown in the glasshouse and carefully examined for the eventual presence of disease.

A further series of germination tests were made on seed of specific grasses for the International Seed Testing Association.

At a Conference of Seed Testing Officers in Adelaide in February 1962, it was decided to recommend to the Agricultural Council that the present Plant Introduction seed reference collection should be regarded as the principal such collection for Australia.

AGRONOMIC EVALUATION OF NEW INTRODUCTIONS

Northern Australia

R.J. Williams

Five hundred new introductions were submitted to initial trial and quarantine screening in the year under review. A large number of species, particularly fodder legumes, emanating from various South-Eastern Asian countries as a result of the visit to that region by Dr. D. Parbery, were included in this total.

Valuable new material is apparent within the leguminous crop species of Cowpea (Vigna sinensis) and Peanut (Arachis hypogaea) and within each of the recognized valuable pasture legumes Centrosema pubescens, Glycine javanica, Phaseolus lathyroides and Stylosanthes gracilis.

New introductions of Phaseolus bracteatus, Indigofera echinata and of perennial species of Dolichos and Vigna merit further investigation in view of their high growth potential revealed in initial nursery trials.

Newly introduced lines of the perennial grasses Paspalum vaguaronense, P. notatum and Panicum maximum of superior yielding ability offer scope for more effective utilization of each of these species.

Preliminary evaluation of lines of the annual forage grass species Pennisetum typhoideum has resulted in the selection of superior lines for seed multiplication and ultimate wider scale evaluation.

Certain introduced grasses have revealed a high level of productivity when grown at Brisbane and a series of agronomic trials has been initiated to determine how this superior growth potential may be utilized to the best advantage.

The trials have been designed (i) to compare the reaction of a number of lines of Setaria sphacelata to various cutting frequencies and levels of nitrogen application; (ii) to study the importance of plant density on the yield of different species of Hyparrhenia sown in association with legumes; (iii) to determine the reaction of a number of lines of Elephant Grass (Pennisetum purpureum) to varying conditions of utilization.

Some introduced lines of Cowpeas have surpassed the commercial Poona variety in grain production in certain regional trials and a further comparative trial of these varieties was established in the summer of 1961-62 at Crooble on a typical Brigalow-Belah soil.

Plant geographical studies of a long-term nature are being undertaken in regard to the distribution, ecology and economic value of tropical legumes. The genus Phaseolus is considered to possess particular significance, following the introduction of four lines of Phaseolus atropurpureus and the successful production of a variety named "SIRATRO" by Dr. E.M. Hutton (of the Division of Tropical Pastures) through the crossing of two of the lines.

A study of the surviving populations from swards arising from the sowing of a known percentage of different ecotypes of Phalaris tuberosa in a number of areas of western New South Wales has revealed that some significant trends in selection have become evident in the 7 year period.

Western Australia

E.T. Bailey

Of the 200 new introductions under trial in 1961, a number of oat and barley varieties and an introduction of Secale montanum have performed well and will be further evaluated.

A comparative trial of lucerne varieties at Kojonup has revealed the superiority of a number of lines, particularly Indian, Hairy Peruvian and some of African origin to Hunter River at all cuts and on two sites.

Three varieties, Lybie, Taguira and Du Puits gave outstanding yields on the poorer soil and the latter variety gave very good late spring and summer production.

The initial stage of commercial seed production has been reached with the Kondinin strain of Rose Clover (Trifolium hirtum) and Trifolium cherleri (CPI 14926).

Selection within Rose Clover has continued and eight basic leaf markings, together with two different superimposed types of spotting, have been recognized.

It is expected that, in addition to Kondinin, an

earlier strain of Rose Clover will be available for commercial distribution in 1963.

The superiority of these Rose Clover lines and two lines of T. cherleri (CPI 13930 and 14926) to other clovers and medics has been revealed in trials at 12 sites in relatively low rainfall areas.

The value of these species in large-scale trials under grazing in comparison with 2 strains of Subterranean clover and of Cyprus Barrel medic will be determined at Carnamah and Lake Grace.

Two introductions of Vicia sativa (CPI 15503, 15504), on the basis of their consistently high yielding performance, have been recommended for commercial release, together with CPI 16627 Vicia atropurpurea, which has equalled the commercial line in herbage production but is earlier maturing and superior in seed yield.

South-Eastern Australia

C.A. Neal-Smith, P. Broué and L. Sharp

Nursery trials of newly introduced pasture plants at Canberra continue to reveal that the most promising species are principally confined to the genera Dactylis, Phalaris, Festuca, Trifolium and Medicago.

A number of lines of Dactylis glomerata and of D. glomerata subsp. hispanica emanating from Italy, Yugoslavia, Turkey and Spain, and of differing degrees of summer dormancy are being subjected to comparative trial in small swards.

A Phalaris tuberosa-Phalaris arundinacea hybrid (CPI 28009) has exhibited a high level of productivity with good initial vigour.

Trifolium vesiculosum (CPI 28583), a late maturing annual clover, Trifolium repens Caladino (CPI 27794) a vigorous, dense, strongly stoloniferous White Clover, and Trifolium pratense (CPI 19431), a longer lived and more winter productive line of Red Clover merit further investigation.

Some lines of White Clover of Mediterranean origin have shown superior drought tolerance to the commercial cultivars and superior winter productivity. The latter characteristic has been

manifested under irrigation at Mitang, South Australia and at Burnley Gardens, Melbourne, to a greater degree than at Canberra owing to the higher winter temperatures at the former localities.

The yield of the perennial grasses Bromus inermis and Festuca arundinacea during the favourable summer season experienced in the Tumut-Tumbarumba region was higher relative to Brignoles Cocksfoot (CPI 2145) but the latter continues to be the most productive species over the whole year.

Distribution of seed of Brignoles cocksfoot has been made to Seed Merchants and seed for commercial use will soon become available.

On a deep sand at Crooble each of the grasses Cenchrus ciliaris (Biloela, Gayndah, Texas and Molopo strains), Digitaria smutsii (CPI 19902), Katambora Rhodes Grass, Chloris gayana (CPI 13375), Cenchrus setigerus (CPI 17655) and Urochloa sp. (CPI 7953) have proved highly persistent and productive. Phaseolus atropurpureus has shown the ability to persist and to spread strongly through native grassland on the same soil type over two summers.

The relative performance of each of these species under grazing will be determined following the provision of watering facilities at the site.

The area of Sorghum almum continues to expand rapidly in North-West and Central West areas of New South Wales, and on the fertile Brigalow-Belah soils Panicum coloratum (Bambatsi) has proved productive under grazing and on one property near Crooble 200 acres have been successfully sown to this species.

Floristic studies

W. Hartley

The fourth of the series of papers on "Studies of the origin, evolution and distribution of the Gramineae" dealing with the genus Poa L., was published during the year. The genus is shown to reach its highest relative specific differentiation in regions of high latitude and high altitude and percentage frequency of species of Poa in the vegetation is largely correlated with cool summer temperatures.

Two papers emphasizing the importance of plant geographical and floristic studies to pasture plant introduction

were presented at the F.A.O. Technical meeting on Plant Exploration and Introduction held at Rome, Italy, in July 1961.

PUBLICATIONS

Andrew, W.D., Neal-Smith, C.A., and Hutchings, R.J. (1962). - Behaviour of leguminous species on moderately saline soil at the Ginninderra Field Station, A.C.T. Field Station Record 1: 41-44.

Bailey, E.T. (1961). - Plant collecting expedition to central Chile 1958-59. C.S.I.R.O. Aust. Div. Plant Ind. Rep. No.21.

Bailey, E.T. (1962). - Regional trials in plant introduction. Field Station Record 1: 29-32.

Bailey, E.T. (1962). - Varieties of common vetch (Vicia sativa L.) Field Station Record 1: 32-37.

Barnard, C. (1961). - The interpretation of the Angiosperm flower. Aust. J. Sci. 24: 64-72.

Broue, P. (1962). - A note on Brignoles cocksfoot. Field Station Record 1: 38-41.

Hartley, W. (1961). - Studies on the origin, evolution and distribution of the Gramineae. IV. The genus Poa L. Aust.J. Bot. 9: 152-61.

Hartley, W. (1961). - The phytogeographical basis of pasture plant introduction and the application of comparative floristic studies to the problem of pasture plant introduction for arid Australia. FAO Tech. Mtg on Plant Exploration and Introduction,Rome 1961. Genet. Agr. (In press)

Hartley, W., and Neal-Smith, C.A. (1961). - Plant introduction and exploration in Australia. FAO Tech. Mtg on Plant Exploration and Introduction, Rome 1961. Genet. Agr. (In press).

Humphries, A.W., and Bailey, E.T. (1961). - Root weight profiles of eight species of Trifolium grown in swards. Aust. J. Exp. Agric. Anim. Husb. 1: 150-2.

Slater, Christine (1961). - Quarterly List of Introductions, Nos. 63, 64 and 65. C.S.I.R.O. Div. Pl. Ind. (mimeo).

TAXONOMIC BOTANY

The correct naming and classification of plants together with information on their natural occurrences are necessary for the investigation of many of the problems in biology and agriculture undertaken within the Division. The Herbarium staff which is responsible for maintaining and improving plant collections also carries out revisions of critical groups of plants and general studies on the distribution and history of the Australian Flora.

Handbook to the Flora of the Australian Capital Territory

Miss N.T. Burbidge

Considerable progress has been made in the preparation of this handbook, which is the main project in hand. Accounts of forty-seven families have been drafted and prepared in mimeographed form. These include a redraft of the Gramineae which has been made available to C.S.I.R.O. officers in Canberra. An account of the Pteridophyta is almost complete. About thirty families await study, including the large families Myrtaceae and Compositae but others are represented in the A.C.T. by only one or two genera. It is intended that the final treatment will be in agreement with that followed in the new Flora of New South Wales.

Work has commenced on the preparation of illustrations. It is hoped to provide a small text figure for each genus discussed.

A draft account covering the Pteridophyta, Gymnosperms and Monocotyledons, with their text figures will be prepared in the near future. In this section the accounts of the Pteridopthyta, Cyperaceae and Orchidaceae will be prepared by Mr.M. Gray.

Several hundred specimens of Mosses have been collected. It may be possible to include an account of them in the Handbook.

During the year a small popular booklet on the "Wattles of the A.C.T." was published by Verity Hewitt Pty. Ltd., of Canberra. A comparable booklet on the local Eucalypts has been prepared but is not yet published.

Phytogeography of the Australian Region

Miss N.T. Burbidge

Following work on this subject, a paper entitled "Plant Cover and Soil Development in the Southern Eremaean Zone during Tertiary and Recent Times" was presented at the Symposium on Geochronology and Land Surfaces in relation to Soils in Australia, in Adelaide in December, 1961.

Service Activities

Identification:- Plant specimens have been identified on behalf of officers of the Division of Plant Industry and other Divisions of C.S.I.R.O., the Australian National University and the general public. This service is thus linked with research in plant introduction, ecological surveys, weeds investigations and other projects.

Herbarium:- During the year, 3979 specimens have been mounted and laid into the collection.

Donations of specimens were received from the Herbarium of the Animal Industry Branch in Alice Springs, from the Brisbane Herbarium, from the British Museum and from the Royal Botanic Gardens at Kew. Voucher specimens for the Phytochemical survey in Queensland have been received from Dr. L.J. Webb. Material received from the Forests Department at Lae, New Guinea, is housed with the other New Guinea collections in the Herbarium of the Division of Land Research and Regional Survey. Dr. H.S. McKee has presented specimens collected in Burma, New Caledonia and Northern Australia.

Collections of special interest include one being made by entomologists in connection with research on phasmids and a collection made by an officer of the Wildlife Survey Section during a visit to the Outer Barrier Reef with a naval survey vessel.

Special collections have been made on field trips, e.g. to the Kosciusko area and central Australia.

PUBLICATIONS

Gray, M. (1961). - A list of vascular plants occurring in the New England Tablelands, New South Wales, with notes on distribution. Contr. N.S.W. Herbarium 3: 1-82.

MICROBIOLOGY

The present Section consists of fourteen research workers and eleven technical assistants, together with one research assistant stationed at Sydney University, and is organized into three teams working around the central theme of "The dynamics of plant-micro-organism associations". Its studies embrace the three major types of association exhibited by plants, namely with fungi, bacteria and viruses.

LEGUME NODULATION AND NITROGEN FIXATION

Examination of Rhizobium by immunochemical methods

W.F. Dudman

The aim of this work is the development of an immunochemical system by which strains of Rhizobium may be characterized and recognized unambiguously. The first experiments are being carried out with two strains of Rh. meliloti: strain 2093 nodulates a group of 8 species of Medicago and Melilotus and also Medicago laciniata, while strain 2097 forms nodules on a different group of thirteen species of Medicago and Melilotus but not on M. laciniata.

Cultures were grown on synthetic medium. Whole cells or ultrasonicated suspensions were used to immunize rabbits for the production of antisera. Gel diffusion and immunoelectrophoresis in agar showed that antisera against whole cell suspensions lacked certain antibodies present in sera prepared against the homologous ultra-sonicated cells. Although the two strains of bacteria used cross-reacted strongly, strain 2093 contained antigens in addition to those of 2097. Electrophoresis of the ultra-sonicates of the two strains on cellulose acetate showed that 2093 contained a protein fraction not found in 2097. Preliminary results only are available, and these are for the extracellular antigens of strain 2097 obtained by high speed centrifugation of whole cell cultures to remove whole cells and suspended matter. After exhaustive dialysis and concentration, the extracellular material was isolated by freeze-drying. Although the material had not been deproteinized, it contained only 0.6 per cent. nitrogen. Analytical centrifugation showed that the material contained two very slow-moving components. Antigenic analysis has proved difficult, but the evidence

suggests that the extracellular material is a mixture of three antigens. The major component is a polysaccharide. Hydrolysis with $\underline{N}.H_2SO_4$ for 1 hour at 100°C released galactose, glucose, xylose and an unidentified fast-moving component. Paper chromatography showed the latter component to have an $R_F 0.90$ in butanol-benzene-pyridine-water (5:1:3:3).

The counting of nodule bacteria

J. Brockwell

Studies have been done with suspensions of cultured bacteria with the objective of attaining maximum accuracy with reasonable replication. Both plate counts and plant infection tests have been used. Errors were found to arise from (i) disruption of small clumps during preparation of dilutions, and (ii) from cell-division which occurs in a burst immediately after dilution. The first effect is small and is minimized by thorough agitation before dilution. The second effect is eliminated by keeping the bacterial suspensions and dilutions at 4°C until inoculation of petri dishes or test plants.

Studies of seed pelleting materials in relation to inoculum survival and nodulation after storage

J. Brockwell

Seed pellets were prepared using ten different coating materials, three adhesives and two different methods of inoculation. The pelleted seeds were sown immediately after preparation, or stored for various periods before sowing, and examined in terms of inoculant survival, nodulation and plant growth. It was found that subterranean clover seed pelleted with a lime, dried blood plus dolomite, or lime plus blood plus dolomite, coating, attached to the seed with a 45 per cent. dispersion of gum arabic in water and inoculated by incorporating a commercial peat inoculant within the pellet could be stored for up to 4 weeks before sowing without loss of viability of the inoculum. This retention of viability of inoculum was shown also in the nodulation and growth of the seedlings when the treated seed was sown into a podzolic soil in which standard inoculation practice has been frequently unsuccessful.

Seed pelleting for dry sowing

J. Brockwell

Work on pre-inoculated, pelleted seed was continued with further experiments in which seed of Medicago tribuloides was treated by incorporating a commercial peat inoculant in a 45 per cent. disperson of gum arabic in water and using the mixture as the adhesive for lime pelleting. Inoculum survival was good in laboratory tests. Seed pelleted in this way was compared with seed treated by other methods of inoculation by sowing into dry soils in the Upper Western Division of New South Wales. Germinating rains fell 3-4½ weeks after sowing and the nodulation of seedlings from seed inoculated as described ranged from 50-76 per cent. and was significantly better than all other methods of inoculation tested at all sites.

Nodulation of clovers as a major factor in improvement of hill pastures

F.W. Hely

Improved inoculation techniques have enabled the relatively cheap establishment of improved pastures on skeletal and other rough hill country in the Goulburn district of southern New South Wales. The methods have been based on the use of heavily inoculated seed of subterranean and other clovers (about 10^6 bacteria per seed) and the use of pelleting. The massive inoculation was obtained by a multi-step process in which the seeds were soaked in broth culture containing about 10^9 bacteria per ml; the seeds, after drying, were then coated with adhesive containing large numbers of bacteria as broth culture and as commercial peat inoculant. The dry pelleting materials were then applied. These extreme measures were necessary because (i) the naturally occurring nodule bacteria in the area are not suitable for the clovers being sown; and (ii) dry sowing is almost always necessary for reasons of access to the land and seed coverage with the machinery used.

Where possible, seed prepared in the above way was sown, mixed with lime and superphosphate, by drilling into moderately grassed undisturbed land by means of ruggedly constructed stump-jump machinery. Where the terrain was too rough for this, the seed was sown, freshly mixed with lime and superphosphate, from the air. The results are summarized below from figures for the percentage of promptly nodulated seedlings found shortly after germination:-

Inoculation	Percentage of promptly nodulated seedlings	
	drilled	air sown*
none	0	0
Standard commercial	0-5	0
Massive	80-98	100*

*Higher numbers of bacteria were used in inoculating seed for aerial sowing.

The estimated extra cost of the massive inoculation was three shillings to three shillings and sixpence per acre when large quantities of seed were involved.

Host and bacterial specificity in symbiotic effectiveness

A.H. Gibson

Lucerne:- In the breeding of improved lucerne varieties the cultivar Rambler has been used as a source of genes for the habit of creeping-rootedness, which is being bred into the varieties Hairy Peruvian and Hunter River. However Rambler does not form effective nodules with a number of normally effective Australian strains of Rhizobium meliloti. This was also found in the F_1 hybrid material Rambler x Hairy Peruvian and Rambler x Hunter River. Effective nodulation of Rambler was obtained with strains of nodule bacteria isolated from nodules of Rambler plants grown in Canada.

Subterranean clover:- Further examination of the ineffective nodulation produced by the bacterial strain NA30 on the variety Northam First Early, has indicated that the effect is under polygenic control. Effective and ineffective selections of F_2 material of the cross Northam First Early x Tallarook showed effective and ineffective responses respectively in F_3, while selections of intermediate effectiveness in F_2 gave in F_3 plants varying from completely ineffective to fully effective. F_2 hybrids from crosses between Northam First Early and other varieties also showed a number of ineffectively nodulated plants when inoculated with NA30, the proportion of such plants varying with the second parent variety.

Saving seed by better establishment of clovers on hill pastures

F.W. Hely

Data from commercial and experimental sowings of Mt. Barker and other varieties of subterranean clover have shown that at elevations of 3,000 feet, only about 15 per cent. of seedlings promptly nodulated by appropriate strains of nodule bacteria, survive the winter months. This has been traced to failure of nitrogen fixation at the low temperatures which occur and the plants dying from severe nitrogen deficiency in early spring. These effects result in considerable seed wastage. Improvement (80-90 per cent. establishment) has been effected by the following measures: (i) sowing earlier so that some nitrogen fixation has occurred before the onset of very low soil temperatures; (ii) application of finely divided calcium carbonate (about one cwt per acre) in the drill rows in addition to that provided by lime coated seeds; (iii) sowing into land with adequate shelter by choosing areas with moderate tussock grass cover and where possible sowing so that the furrows provide shelter from the prevailing winds.

The effects of root temperature on the nodulation and nitrogen fixation of subterranean clover

A.H. Gibson

Work has continued on the influence of root temperature upon nodulation and nitrogen fixation using subterranean clover as the experimental plant, and a range of strains of *Rhizobium trifolii*. Low root temperatures (5 and 14°C) retarded the formation of nodules on all varieties of subterranean clover tested. Plants which had been nodulated at low temperatures fixed less nitrogen than did those nodulated at 20° and subsequently subjected to low root temperatures. Nitrogen fixation by nodulated plants of varieties Tallarook and Dwalganup was affected by variety, root temperature, and bacterial strain used. At 10° and 22°C some strains of nodule bacteria isolated from regions of high elevation proved more effective than standard strains.

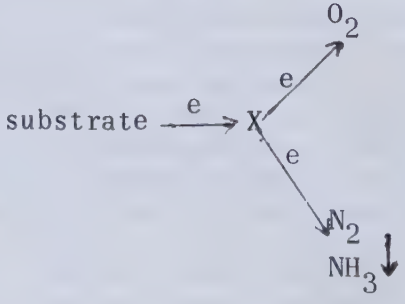
Rates of growth and nitrogen fixation by the varieties Mt. Barker and Yarloop inoculated with two strains of *Rhizobium trifolii* were measured at various temperatures over the 20 day period following nodule formation. Both plant growth and nitrogen fixation followed exponential curves the slope of which

varied with temperature and bacterial strain. Root temperature was found to affect both the percentage nitrogen and distribution of N within the plants. At 5^{o} and 10^{o}C the percentage N of the shoots was lower than that of the roots; at 14^{o}-22^{o}C the percentage N of shoots and roots was equal and at 30^{o}C the percentage N of shoots was greater than that of the roots.

The effects of external oxygen tension (pO_2) on nitrogen fixation by detached soybean nodules

F.J. Bergersen

The respiration of intact detached soybean nodules increases with increasing pO_2 with an inflection or plateau occurring, for active nodules, at about 50 per cent. O_2. Nitrogen fixation by such nodules increases with pO_2 to a maximum and then at higher levels of O_2 is inhibited. Concurrent measurements of respiration and nitrogen fixation (using ^{15}N as a tracer) at various pO_2 values clearly showed that the inflection in the respiration/pO_2 curve corresponded with the maximum of the fixation/pO_2 curve. This point of correspondence varied with nodule age, occurring at about 50 per cent. O_2 for nodules aged 20-30 days, but being found at lower values with increasing age, until neither inflection nor fixation could be detected at about 42-45 days. Experiments at various N_2 and O_2 tensions showed that nitrogen fixation was competitively inhibited by O_2 at pO_2 values higher than 60 per cent. for active nodules. The data were consistent with competition for a single enzyme reactive site but because of the great dissimilarity between the N_2 and O_2 molecules it is most unlikely that the competition occurs at the N_2 activating site. It is considered more likely that the competition occurs at some common point in the respiratory and N-fixing pathways of electron transport:



From consideration of nodule structure and the respiration effects described above, it has been deduced that active tissue of soybean nodules is characterized by regions of very low O_2 tension within a barrier which prevents penetration of O_2 until a certain external pO_2 has been exceeded. When it penetrates beyond this barrier, O_2 competes with N_2 for the reducing power generated in the bacteroids which are packed within the cells of the active tissue. This hypothetical barrier may be one or more metabolic screens which quickly absorb penetrating O_2, or may be a permeability barrier which could be located in the membrane envelopes which enclose bacteroids and haemoglobin within the cells.

The effects of external oxygen tension on the haemoglobin of detached soybean nodules

F.J. Bergersen

Spectroscopic examination of nodules exposed to various pO_2 values clearly showed that no detectable increase in the amount of oxyleghaemoglobin occurred with increasing pO_2 until a certain value had been exceeded. This value corresponded well with the value above which nitrogen fixation was inhibited in other experiments. For active nodules, (about 30 days old), only one per cent. or less of the pigment was oxygenated at external pO_2 below 50 per cent. Above 50 per cent. the haemoglobin became progressively more oxygenated, the increase on oxygenation continuing up to 100 per cent. O_2. From the known high affinity of leghaemoglobin for O_2, an oxygen tension of the order of 0.001 per cent. is indicated in the haemoglobin-containing regions of nodules exposed to air.

INFECTIVITY AND LESION PRODUCTION OF TMV

The effect of ultra-violet irradiation on the "capacity" of Nicotiana glutinosa leaves

D.J. Goodchild

Tobacco mosaic virus forms local necrotic lesions when inoculated on to leaves of N. glutinosa. In this system, the effect of UV on the host plant is expressed as an effect on the host's "capacity", which is defined as the ability of a leaf to support the multiplication of TMV to the extent of forming local lesions.

With UV from a germicidal lamp providing energy at 600μ watts/cm^2, capacity is impaired if the average time of exposure of leaves to UV exceeds 90 seconds when glasshouse-grown N. glutinosa plants are held for 16 hours at 25°C and in continuous light of 800 ft. candles intensity before irradiation and, following irradiation, until lesions are counted. If leaves are retained in the dark following UV treatment, the average time of exposure to UV that impairs capacity is reduced, as is also the case if plants are retained in the dark before and after UV treatment. Thus, capacity can be photoreactivated. At different times of the year the UV dose necessary to impair capacity varies, presumably reflecting the physiological condition of the host plant.

A second effect of the impairment of capacity can be demonstrated when the rates of appearance of local lesions from impaired and non-impaired leaves are compared. When capacity is impaired, lesions develop at a slower rate.

The effect of ultra-violet light on tobacco mosaic virus

D.J. Goodchild

Ultra-violet irradiation of TMV causes an exponential decrease in infectivity according to a one-hit relationship. The rate of appearance of local lesions of TMV on N. glutinosa has been used as a measure of the rate of virus multiplication. It can be shown that rate of appearance of local lesions from UV-irradiated TMV is slower than that from native TMV. This effect is not due to any interference phenomenon of killed particles in the inoculum competing with surviving particles. Furthermore, lesion appearance is slower when infectious TMV-RNA is irradiated and used as the inoculum, indicating that the UV effect is on the nucleic acid portion of TMV and not on the protein coat of the virus. Studies were made with TMV irradiated with x-rays, but no delay in the rate of appearance of lesions was demonstrable.

It appears that a fraction of TMV particles surviving UV-irradiation require a longer period of time to multiply and thus appear to be affected in a sub-lethal manner by UV.

Masking of local lesions and the biology of infections of tobacco mosaic virus on Pinto bean

Katie Helms

On Pinto bean leaves maintained at 25°C, numbers of macro

lesions (macroscopically identifiable necrotic lesions) of TMV-U_2 but not of TMV-U_1, decreased between two and six days after inoculation. This disappearance of macro-lesions was examined in a study of the biology of infection of TMV-U_2 as compared with that of TMV-U_1. It was found that lesions of TMV-U_2 remained detectable at high magnification on bleached, iodine stained leaves. During the period of the experiments, inoculated leaves expanded. Areas of lesions of TMV-U_2 reached a maximum at two days, whereas areas of lesions of TMV-U_1 continued to increase in size during a period of five days. The mean maximum lesion area for TMV-U_2 and TMV-U_1 was 0.91×10^{-2} and 4.58×10^{-2} sq.mm. respectively. Lesions of TMV-U_2 and TMV-U_2-RNA appeared earlier and more synchronously than those of TMV-U_1 and TMV-U_1-RNA. The mean time of appearance of 50 per cent. macro lesions of TMV-U_2 and TMV-U_2-RNA was 29.4 and 27.5 hours respectively; for TMV-U_1 and TMV-U_1-RNA it was 47.6 and 34.5 hours respectively. The mean time of appearance of 50 per cent. starch lesions (necrotic lesions recognizable on bleached, iodine stained leaves at a magnification of 10X) was later than for macro lesions.

It was concluded that the time-course decrease in numbers of macro lesions of TMV-U_2 was due to masking of lesions caused by post-inoculation expansion of leaves in association with rapid but limited growth.

Some causes of variation in lesion size of tobacco mosaic virus infections on Pinto bean

Katie Helms and G.A. McIntyre (Division of Mathematical Statistics)

Measurements of the relative numbers of lesions detectable as macro and starch lesions were used in an examination of causes of variation in size of lesions of strain U_1 TMV on Pinto bean leaves.

Numbers of macro lesions relative to starch lesions increased significantly with increase in virus concentration. The rate of increase per doubling of virus concentration was approximately one per cent. This increase could be due to the occurrence of composite lesions, to multiple infections of primary invaded cells causing a greater probability of infection of adjacent cells, or to heterogeneity of infective particles in the inoculum such that some particles tend to form larger lesions than others.

There were significant differences in the ratio of macro to starch lesions between leaf discs sampled from two positions within leaves, and from leaves inoculated at 8 and 11 days after sowing. These differences could not be accounted for by variations in technique of the operator during inoculation. It was concluded that the heterogeneity between areas within and between leaves with respect to lesion size must be due to intrinsic variation between cells of the disc samples in their potentiality to develop macro or micro lesions. By implication this also would be true for groups of cells within discs.

Virus diseases of legume pasture plants

D.J. Goodchild

A disease affecting the yield of white clover pasture was reported during the spring of 1961 from Deniliquin. Subsequent glasshouse tests have confirmed that lucerne mosaic virus and another, as yet undetermined, virus are involved. This appears to be the first reported instance of lucerne mosaic virus causing economic losses in plant production in Australia.

HOST PATHOGEN RELATIONSHIPS IN FUNGI

Studies on the disease reaction in plants with particular reference to the phytoalexin theory

I.A.M. Cruickshank and Dawn R. Perrin

The long term objective of this study is an investigation of the chemical basis of disease resistance in plants, and the phytoalexin theory of Müller and Börger is being examined. An antifungal substance (phytoalexin) to which the name "Pisatin" was given, was isolated from fungus-infected tissues of the garden pea, Pisum sativum L. and studies are now in progress to investigate the "phytoalexins" from other host plants. A more detailed study of various physiological factors affecting pisatin production by the endocarp tissue of the pea pod has been made. The rate of formation of pisatin and its total concentration have been measured in a range of experiments covering variations in the host plant (maturity, previous conditions of storage), the fungus (both pathogens and non-pathogens of peas over a concentration range) and conditions affecting both the fungus and the host plant such as temperature and anaerobic conditions. The production of pisatin by the endocarp tissue following the

application of fluids in which spores had germinated, and then been removed, has demonstrated that the presence of fungal spores is not necessary to stimulate pisatin formation. It is suggested that pisatin formation is initiated by some chemical substance produced by the fungal spore during germination. Very dilute solutions of certain chemicals, especially heavy metal ions, such as copper, mercury and silver are also able to induce pisatin formation and this chemical production of pisatin is being used in preliminary studies on investigating the origin of pisatin in the pea plant tissues.

The structural chemistry of pisatin

Dawn R. Perrin with W. Bottomley (Biochemistry Section) and D.D. Perrin (Dept. of Medical Chemistry, Australian National University)

More detailed examination of the NMR spectrum of pisatin and pterocarpin suggested that although pisatin is a hydroxyl pterocarpin, the accepted chemical structure for pterocarpin might be in error. This suggestion was since confirmed by the publication by two overseas workers of a revised structure for pterocarpin. The assignment to pisatin of the structure, 3-hydroxy 7-methoxy 4'5'-methylenedioxy chromanocourmarane is consistent with all chemical and physical results obtained during the investigations on the structure of pisatin.

Factors affecting pisatin formation in pods of Pisum sativum L.

I.A.M. Cruickshank and Dawn R. Perrin

The capacity of fungi to stimulate the formation of pisatin in the tissues of Pisum sativum is not limited to any particular taxonomic class or nutritional type of fungus. In quantitative tests it has been shown that with the exception of pea pathogens the concentrations of pisatin formed are in excess of the ED_{50} values of the fungi used as inocula. The form of the time-course curve of pisatin formation is multi-inflexional, a plateaux or an inflexion occurring between 36 and 60 hours after inoculation. No consistent differences exist between pathogens and non-pathogens of peas in relation to rate of pisatin formation. However, within the group of pea pathogens studied, Ascochyta pisi induced the formation of high concentrations (>100µg/ml) while Septoria pisi induced the formation of low concentrations (>10µg/ml). These differences are of significance to susceptibility when considered in relation to the ED_{50}

values of pisatin for both of these fungi. The results suggest that susceptibility may be due to the capacity of an infecting fungus to be tolerant of the phytoalexin produced in its host plant tissues or its relative inability to stimulate phytoalexin formation.

The effect of light on sporulation of Peronospora tabacina in the leaf tissues of tobacco

I.A.M. Cruickshank

The sporulation inhibition previously demonstrated under continuous white light (10 ft. candles) has been shown to be due to wave-lengths in the 4700Å to 5200Å region of the spectrum (energy level 1.5 μw per sq.cm). At the same energy level no significant inhibition of sporulation was observed in either the infra-red or ultra-violet regions of the spectrum.

The epidemiology of Brown Rot of stone fruits

J.B. Corbin

Data accumulated this year, together with previous information, allows the following statements: (i) greatest infection with Monilinia fructicola occurs at either or both flowering and harvest times. No spread of infection appears to occur during the winter months; (ii) infection of green fruit can be extensive and depends largely on the presence of injuries and a high inoculum potential; (iii) sporulation can occur in the field throughout the year. During the summer, the main source is on infected ripening fruit. During the winter sporulation can occur on peduncles, twig cankers and mummified fruit. The fungus can overwinter in these structures as conidia, or as dormant mycelium; (iv) epiphytotics appear capable of development under various climatic conditions. Low rainfall spread over a long period appears to be equally, or more, conducive to epiphytotic development, than high rainfall over a short period.

Factors determining the length of incubation period of Monilinia fructicola in fruits of Prunus species

J.B. Corbin

The time for completion of the incubation period, which was defined as the interval between application of conidia to fruits and the first appearance of sporulation, was studied on

fruits of several Prunus species. Results were expressed as the time required for 20 per cent. and 50 per cent. of the fruits to produce sporodochia. Differences between species, at similar inoculum levels, were greatest when fruits were least mature and non-injured, these differences disappearing as fruits matured and as the extent of skin injuries increased.

Green fruits were infected more readily when injured. Ripe fruit, whether injured or uninjured, were infected rapidly at low inoculum levels.

Ambient air humidity did not affect sporulation of the fungus on Prunus fruits and the results indicate that, under field conditions, broken fruit tissues can sporulate under low humidity conditions. However, it is clear that moisture, or long periods of high humidity are necessary for germination of the fungus on non-injured fruit surfaces.

The effect of water relations and temperature on sporulation of Monilinia fructicola

J.B. Corbin and I.A.M. Cruickshank

The role of water relations in determining sporulation level was studied on Prunus armeniaca L. cv. Trevatt. Sporulation was induced on fruits, leaves, water-soaked peduncles and mummified fruitlets. Sporulation was initiated after 12 hours incubation and reached a maximum after 36-44 hours. Temperature optima for sporulation were 19.3°C for peduncles and 12.3°C for mummified fruitlets.

In living turgid tissues, relative humidity did not affect the sporulation level, but in dormant and dead tissues (peduncles and mummified fruitlets) sporulation was greatest at high relative humidities and decreased rapidly at lower levels.

Sporulation level correlated with the moisture content of the host tissues, being greater on water-soaked than on air-dried tissues. Under certain combined treatments of high plus low relative humidities, sporulation was greater than under conditions of continuous high relative humidity.

Longevity of conidia of Peronospora tabacina Adam.

A.V. Hill

Conidia were produced on discs cut from infected leaves in the presporulation stage. These discs were stored at

differing relative humidities and at various temperatures. Such discs were taken at intervals, the conidia washed off and a drop of the suspension so obtained was incubated for 24 hours at 15°C on an agar block, after which period the degree of germination was assessed. The results, shown in the Table below, indicate the period in days over which germination occurred in conidia stored under various temperature and humidity conditions.

Longevity of conidia of P. tabacina

Temperature °C	30	25	20	15	10	5
Relative humidity % RH	Days at which <1% survival was recorded					
100-80	0	2	9	6	12	12
80-70	0	5	9	21	30	46
70-50	-	8	14	-	-	-
50-40	0	10	-	43	-	-
40-30	-	21	36	75	106	131
30-20	-	29	69	-	-	-
20-10	-	42	106	22	-	-
Nominal nil	3	5	13	15	20	20

The results show that optimum longevity of conidia at various temperatures did not occur at the same relative humidity. As temperature increases, optimum longevity occurs at lower relative humidities. If the results are considered in terms of water potential, then maximum longevity at all temperatures occurs at approximately the same water potential value.

It would appear that hot, dry, conditions such as may occur in field or glasshouse, cannot be expected to eliminate conidial spread of P. tabacina.

Resistance of seedlings of Nicotiana species to Peronospora tabacina Adam.

A.V. Hill and M. Mandryk

Seedlings of Nicotiana species of Australian and American origin were tested for resistance to an Australian strain of P. tabacina. American species were less resistant than Australian species and differences in results of similar tests in both countries could have been due to differences in the pathogens or in the seed lines tested.

The data suggest that the pathogen would have difficulty in surviving on the highly resistant Australian species of Nicotiana in their natural arid habitat. Field observations have shown that survival occurs on the introduced susceptible species of N. tabacum and N. glauca.

The data are summarized in the accompanying Tables:

TABLE 1. Resistance to Peronospora tabacina in seedlings of Australian species of Nicotiana

Group and Species	Age of plants at inoculation: 14 days T/	14 days D≠	24 days T	24 days D	35 days T	35 days D
	mean disease rating +					
Immune to highly resistant						
N. exigua Wheeler	0	0	0	0	0	0
N. debneyi Domin	0	0	0	0	0	0
N. occidentalis Wheeler sub.sp. obliqua	trace	1.0	0	0	0	0
N. rosulata Domin	0	0	0	0	0.2	2.0
N. cavicola N.T.Burbidge	0.3	1.5	0.4	1.3	trace	1.1
N. simulans N.T.Burbidge	0.2	2.1	trace	1.8	0	0
N. megalosiphon Heurk & Muell.	0.2	1.7	0.5	2.0	0.2	1.2
Moderately resistant						
N. gossei Domin	0.7	2.1	1.5	2.2	1.2	2.1
N. goodspeedii Wheeler	0.7	2.0	trace	2.0	0.5	2.0
N. amplexicaulis N.T. Burbidge	0.7	1.9	0.9	1.9	0.1	1.7
N. velutina Wheeler	0.5	2.0	0.9	1.8	0.6	1.5
N. megalosiphon Heurk & Muell.	0.8	2.1	0.5	1.7	0.7	1.8
N. rotundifolia Lindley sub.sp. rotundifolia	1.2	2.4	1.1	2.6	0.7	1.5
Résistant						
N. umbratica N.T.Burbidge	1.9	2.3	2.2	3.0	2.0	3.0
N. suaveolens Lehm	1.9	2.7	1.8	2.3	1.4	2.4
N. goodspeedii Wheeler	2.9	3.0	2.7	2.9	2.6	2.9
Susceptible to very susceptible						
N. umbratica N.T.Burbidge	4.8	4.8	4.9	4.9	5.0	5.0
N. benthamiana Domin	3.4	3.8	2.9	3.6	3.7	3.7
N. tabacum L. cv. Virginia Gold	4.1	4.2	4.1	4.1	3.7	3.7

/ Total mean value of all plants + Rating 1-5
≠ Mean value for diseased plants only

TABLE 2. Resistance to Peronospora tabacina in seedlings of American species of Nicotiana

Group and species	Age of plants at inoculation 14 days T/	14 days D≠	24 days T	24 days D	35 days T	35 days D
	mean disease rating +					
Resistant						
N. repanda Will.	2.2	2.2	1.3	1.7	2.5	2.5
Susceptible to very susceptible						
N. glauca Graham	1.6	3.2	3.0	3.8	3.0	3.0
N. longiflora Car.	3.2	3.4	3.2	3.2	2.5	2.5
N. glutinosa L.	1.8	2.6	3.8	3.8	3.0	3.0
N. acuminata (Graham) Hooker	3.1	3.1	3.4	3.4	3.2	3.2
N. paniculata L.	2.7	2.8	3.8	3.8	2.7	2.7
N. rustica L. (cv. Pumila)	3.6	3.6	1.8	2.3	2.0	2.0
N. sylvestris Speg & Comes	4.7	4.7	3.0	3.0	2.0	2.3
N. sanderae Hort & Watson	4.9	4.9	2.9	2.9	2.3	2.3
N. rustica L. (cv. Brasilia)	4.4	4.4	3.0	3.0	3.3	3.3
N. alata Link & Otto	4.8	4.8	4.5	4.5	3.0	3.0
N. trigonophylla Dunal	4.6	4.6	4.2	4.2	4.2	4.2

/ Total mean value, all plants + Rating 0-5
≠ Mean value for diseased plants only

The effect of various compounds on sporulation of Peronospora tabacina Adam. in vitro

M. Mandryk

Infected leaf discs, in the presporulation phase, were floated on solutions of various metabolites and inhibitors. After sporulation had occurred, its extent was measured by washing the spores from the discs and measuring the number produced by haemocytometer slide counts. The results are summarized below:

(i) Of the vitamins tested, nicotinic acid, p-aminobenzoic acid, pyridoxin, choline, pantothenic acid, biotin and riboflavin stimulated sporulation. In particular, with biotin and riboflavin (10 µg/ml), twice as many spores were produced as in the water controls.

(ii) Of 35 purines and pyrimidines tested, stimulation of sporulation was observed with thymine, cytidine, 8-aza-xanthine, uracil and 5-nitrouracil. Inhibition was observed in the presence of uracil-4-acetic acid, caffeine, inosine, diazauracil, 6-aza-uracil and dithiouracil.

(iii) Of 37 amino-acids and their analogues tested, slight stimulation was observed with glutamic acid, histidine, isoleucine, leucine, tyrosine, tryptophan, alanine, homocysteine, methionine, proline and β-alanine. Inhibition was observed with canavanine, ethionine, β-4-furyl-alanine, cysteic acid, hydroxyproline and glycine. The canavanine inhibition could be counteracted only by the addition of ornithine, citrulline, arginine, proline, aspartic acid and glutamic acid.

(iv) The addition of sugars, fatty acids and phosphates showed either no effects, or produced slight stimulations.

Germination of conidia of Peronospora tabacina Adam.

In vitro studies

C.J. Shepherd

These studies have been concluded, the more important findings being summarized below:

(i) The presence of a germination inhibitor was shown in unwashed conidia. This could be readily removed by washing.

(ii) Washed conidia exhibit a requirement for riboflavin. In the absence of riboflavin, germination was negligible.

(iii) The rate of germination was enhanced, in the presence of adequate riboflavin, by the further addition of available carbon and nitrogen sources, phosphate, calcium and magnesium ions. The results have led to the development of a synthetic medium in which maximum

germination occurs in 2-3 hours.

(iv) The optimum temperature for maximum germination was in the range 15^{o}-20^{o}C. However, the rate of germination was more clearly optimal at about 15^{o}C and was affected by the constitution of the suspending medium.

(v) The pH optimum varied with the constitution of the medium; on agar a broad optimum was shown at pH's 5.5-8.0, whereas on glass in the presence of riboflavin, a much narrower optimum was observed in the range pH's 6.5-7.5.

(vi) Visible light did not affect germination, but 9000μ watts/cm^2 of ultra-violet light reduced it to 2.7 per cent.

(vii) Washed spores showed no loss of germination capacity when kept for up to 6.5 hours, but germination fell on subsequent storage and was negligible after 18 hours.

(viii) When conidia were tested within 24 hours of the induction of sporulation, germination was high (85 per cent), but after 48 hours and 72 hours germination had fallen to 61 per cent. and 43 per cent. respectively.

Germination of conidia of Peronospora tabacina Adam.

In vivo studies

C.J. Shepherd and M. Mandryk

These studies have been concluded and the results are summarized below:

(i) Germination of conidia on leaves of Nicotinia tabacum cv. Virginia Gold (a highly susceptible species) was shown to be surprisingly low, being approximately 3-4 per cent., as compared to agar control values of 90-95 per cent.

(ii) Typical riboflavin deficiency symptoms were observed and the addition of 20 μg/ml riboflavin increased germination to40-45 per cent.

(iii) If the leaves were washed extensively with water before inoculation, germination in the presence of riboflavin

reached the level of the agar controls. In the absence of riboflavin, germination on washed leaves was in the range 60-65 per cent.

(iv) Water washings from leaves were shown to contain a mixture of substances inhibitory to conidial germination. These substances have been partly characterized as phenolics and are considered to be the normal constituents of the gum on such leaves. The amount of inhibitor was low in the lower leaves of Virginia Gold plants and high on the upper, immature leaves. This is in inverse relationship to the susceptibility to blue mould infection of such leaves and it is suggested that the differential susceptibility of upper and lower leaves to blue mould infection may be explained in terms of the concentration of inhibitory materials present on their surfaces.

(v) Exhaustive washing renders all leaves equally susceptible to infection. The importance of this in the epidemiology of the fungus is that rain not merely provides moisture for germination, but also removes the leaf surface inhibitor. Thus germination of the leaves of Virginia Gold is controlled by a balance between the amount of available riboflavin and the amount of surface inhibitor present.

The basis of resistance of Nicotiana debneyi to blue mould infection

C.J. Shepherd and M. Mandryk

The *in vivo* germination studies reported above suggested a possible mechanism for the immunity of *N. debneyi*. However, germination on the leaves of *N. debneyi* was in the range of 75-80 per cent. and could be increased to agar control values (90-95 per cent.) by preliminary washing of the leaves. No evidence of riboflavin deficiency was obtained. Thus the peculiar situation exists where germination on the leaf is severely limited in a susceptible species, but is virtually unimpaired on an immune species. In both species, many of the conidia that germinate, penetrate the leaf surface. In *N. tabacum* subsequent mycelial growth is vigorous and all the leaf tissues are invaded. In *N. debneyi*, cytological examination has shown that a very small colony of the fungus is produced following penetration, but that the mycelium is restricted to the space between the

epidermis and the underlying tissues. It is suggested that N. debneyi is resistant to blue mould because the fungus cannot form its normal association with the palisade and spongy mesophyll tissues of the leaf. Penetration of these tissues is prevented in some way that is at present obscure.

Induced resistance to blue mould in stem-infected tobacco

C.J. Shepherd, M. Mandryk, W. Bottomley and J.G. Wilson (Biochemistry Section)

A possible explanation of the chemical basis of immunity of stem-infected N. tabacum plants to foliar infection has been suggested previously (Annual Report 1960/61). A large scale preparation of the active material is in progress. Approximately one ton of tobacco has yielded 140 gallons of ethanolic extract containing some 30 million units of stem-infection-factor activity. The purification and characterization of the active material is in progress.

PUBLICATIONS

Bergersen, F.J. (1961). - The growth of Rhizobium in synthetic media. Aust. J. Biol. Sci. 14: 349-60.

Bergersen, F.J. (1961). - Haemoglobin content of legume root nodules. Biochim. Biophys. Acta 50: 576-8.

Bergersen, F.J. (1961). - Nitrate reductase in soybean root nodules. Biochim. Biophys. Acta 52: 206-7.

Bergersen, F.J. (1962). - The effects of partial pressure of oxygen upon respiration and nitrogen fixation by soybean root nodules. J. Gen. Microbiol. (In press).

Bergersen, F.J. (1962). - The oxygenation of leghaemoglobin in soybean root nodules in relation to the external oxygen tension. Nature, Lond. (In press).

Bergersen, F.J., Burris, R.H., and Wilson, P.W. (1961). - Biochemical studies on soybean nodules. In "Recent Advances in Botany", (University of Toronto Press) Montreal 1959. pp. 589-93.

Brockwell, J. (1962). - Studies on seed pelleting as an aid to legume seed inoculation. I. Coating materials, adhesives and methods of inoculation. Aust. J. Agric. Res. 13: (In press).

Brockwell, J., and Hely, F.W. (1961). - Symbiotic characteristics of Rhizobium meliloti from the brown acid soils of the Macquarie region of New South Wales. Aust. J. Agric. Res. 12: 630-43.

Brockwell, J., and Hely, F.W. (1962). - Relationship between viability and availability of Rhizobium trifolii introduced into seeds of Trifolium subterraneum L. by imbibition and pressure. Aust. J. Agric. Res. (In press).

Brockwell, J., and Ludbrook, W.V. (1962). - The response to phosphates of Pinus grown on infertile soils in New South Wales. I. P. elliotii and P. taeda in the South Coast Region. 2. P. radiata in the Southern Tablelands region. C.S.I.R.O. Div. Pl. Ind. Rept. 22. (In press).

Brockwell, J., and Whalley, R.D.B. (1962). - Incorporation of peat inoculant in seed pellets for inoculation of Medicago tribuloides Desr. sown into dry soil. Aust. J. Sci. (In press).

Cruickshank, I.A.M. (1961). - Sporulation as a factor in the epidemiology of disease development. A Review. Proc. Plant Path. Conf. pp. 12-1 to 12-10.

Cruickshank, I.A.M. (1962). - Studies on phytoalexins. IV. The antimicrobial spectrum of pisatin. Aust. J. Biol. Sci. 15: 147-59.

Cruickshank, I.A.M., and Perrin, Dawn R. (1961). - Studies on phytoalexins. III. The isolation, assay, and general properties of a phytoalexin from Pisum sativum L. Aust. J. Biol. Sci. 14: 336-48.

Cruickshank, I.A.M., and Perrin, Dawn R. (1962). - Studies on phytoalexins. VI. Pisatin: the effect of some factors on its formation in Pisum sativum L., and the significance of pisatin in disease resistance. Aust. J. Biol. Sci. (In press).

Dudman, W.F., and Grncarevic, M. (1962). - Determination of surface waxy substances of grapes. J. Sci. Fd. Agric. (In press).

Gibson, A.H. (1961). - Root temperature and symbiotic nitrogen fixation. Nature, Lond. 191: 1080-1.

Gibson, A.H. (1961). - Symbiotic nitrogen fixation: the poor relation in legume breeding. Proc. Conf. Cereal and Pasture Plant Breeders. pp. 33-1 to 33-7 (Australia).

Gibson, A.H. (1962). - Genetic variation in the effectiveness of nodulation of lucerne varieties. Aust. J. Agric. Res. 13: (In press).

Goodchild, D.J. (1961). - Current views on the classification of plant viruses. Proc. Plant Path. Conf. Vol.1, pp. 1-1 to 1-7. Adelaide, Oct.

Goodchild, D.J. (1961). - The photo-reactivation of tobacco mosaic virus in vivo. Nature, Lond. 192: 289-90.

Helms, K. (1962). - Strawberry, clover, and pea as hosts of big bud virus. Aust. J. Biol. Sci. 15: 278-80.

Hely, F.W., and Brockwell, J. (1962). - An exploratory survey of the ecology of Rhizobium meliloti in fine-textured and coarse-textured soils of the upper plain tract of the Darling River. Aust. J. Agric. Res. 13: (In press).

Hely, F.W. (1962). - Relationship between effective nodulation and time to initial nodulation in a diploid line of Trifolium ambiguum M. Bieb. Aust. J. Biol. Sci. (In press).

Hely, F.W. (1962). - Frequencies of annual species of Medicago on subgroups of the grey and brown soils of heavy texture of the Macquarie region of New South Wales. Aust. J. Agric. Res. 13: (In press).

Hill, A.V. (1962). - Longevity of conidia of Peronospora tabacina Adam. Nature, Lond. (In press).

Hill, A.V. (1962). - Soil as a factor in the incidence of Peronospora tabacina Adam. on tobacco. Aust. J. Agric. Res. (In press).

Hill, A.V., and Mandryk, M. (1962). - Resistance of seedlings of Nicotiana species to Peronospora tabacina Adam. Aust. J. Exp. Agric. Anim. Husb. 2: 12-15.

Mandryk, M. (1961). - Acquired resistance to Peronospora tabacina in Nicotiana tabacum. Proc. Plant Path. Conf. Vol. 1, pp. 48-1 to 48-2. Adelaide, Oct.

Mandryk, M. (1962). - The relationship between acquired resistance to Peronospora tabacina in Nicotiana tabacum and soil nitrogen levels. Aust. J. Agric. Res. 13: 10-16.

Perrin, D.D., and Perrin, Dawn R. (1962). - The n.m.r. spectrum of pisatin. J. Amer. Chem. Soc. (In press).

Perrin, Dawn R., and Bottomley, W. (1961). - Pisatin, an antifungal substance from Pisum sativum L. Nature, Lond. 191: 76-7.

Perrin, Dawn R., and Bottomley, W. (1962). - Studies on phytoalexins. V. The structure of pisatin, a phytoalexin from Pisum sativum L. J. Amer. Chem. Soc. (In press).

Perrin, Dawn R., and Cruickshank, I.A.M. (1961). - The isolation characterization and properties of a phytoalexin from Pisum sativum L. Proc. Plant Path. Conf. Vol. 1, pp. 25-1 to 25-9, Adelaide, Oct.

Rider, N.E., Cruickshank, I.A.M., and Bradley, E.F. (1961). - Environment and sporulation in phytopathogenic fungi. III. Peronospora tabacina Adam: field environment, sporulation, and forecasting. Aust. J. Agric. Res. 12: 1119-25.

Shepherd, C.J. (1961). - Fungal variation in relation to pathogenicity. Proc. Plant Path. Conf. Vol. 1, pp. 27-1 to 27-10, Adelaide, Oct.

Shepherd, C.J. (1962). - Germination of conidia of Peronospora tabacina Adam. I. Germination in vitro. Aust. J. Biol. Sci. 15: (In press)

Shepherd, C.J., and Mandryk, M. (1962). - Autoinhibitors of germination and sporulation in Peronospora tabacina Adam. Trans. Brit. Mycol. Soc. 45: (In press).

Shepherd, C.J., and Mandryk, M. (1962). - A technique for growing Peronospora tabacina Adam. in vitro on tobacco leaf discs. Aust. Plant Dis. Rec. 14: (In press).

GENERAL CHEMISTRY AND SOIL FERTILITY

The research activities of this Section are concerned largely with two major and closely related aspects of soil fertility; (i) the chemical nature of the essential plant nutrients as they exist in the soil and the chemical and biological factors which govern their availability to plants; (ii) the effects of different cropping or agricultural systems on the overall fertility of soils, such as the influence of applied fertilizers on the soil; the amounts and chemical nature of their components remaining in the soil, and the availability of these to plants; changes in the amount of organic matter as a result of cultivation to plants of the constituent elements (nitrogen, sulphur and phosphorus) and of other plant nutrients (potassium, calcium and magnesium).

The Section also provides a routine analytical service to other Sections of the Division.

PHOSPHORUS AVAILABILITY

The chemical nature of organic phosphorus

D.J. Cosgrove

In most soils a major proportion of the total phosphorus is unavailable to plants. Included in this is the organic phosphorus which generally comprises at least one-third of the total. Little is known of the true nature of the phosphorus-containing substances in soil organic matter and work is being carried out to attempt the separation and identification of organic phosphorus compounds in Australian soils. Investigations have been directed in the first place towards an examination of inositol phosphates.

Examination of phytate preparations from soils by gradient elution with 0-1.5 N hydrochloric acid from a column of anion-exchange resin has shown that as well as myo-inositol hexaphosphate, these preparations also contain dl- and scyllo-inositol hexaphosphate. In addition, lower phosphate esters of some or all of these have been found. At least two other unidentified phosphates have also been isolated from these preparations. Of the inositol isomers identified in the soil preparations, only myo-inositol has previously been found in the

phosphorylated form in nature.

The remainder of the soil organic phosphorus appears to be mainly polymeric in character and attempts are being made to degrade it to recognizable phosphorylated fragments.

Phosphate retention in acid soils

S.M. Bromfield

Both iron and aluminium compounds contribute to the adsorption and retention of phosphate in soils but little precise information is available of the relative importance of the roles played by these two groups of compounds. Investigations, initiated at the Macauley Institute, Aberdeen, have been continued at Canberra.

The first part of this study was to devise a method which would specifically remove iron but not aluminium from soil. This has now largely been achieved. Briefly, the method involves an initial hydrogen peroxide treatment followed by an anaerobic fermentation with sucrose and a washing with sodium chloride. The specificity of the method for iron is obtained by careful control of pH during the fermentation. The precise control of variables required to always reproduce the desired conditions is not yet fully understood but successful extraction of iron has been achieved on a number of soils.

A second stage of this investigation is to determine the extent to which phosphate sorption is decreased following the removal of iron and aluminium from a wide range of soils. This phase has only recently been commenced, but a preliminary result on one soil indicates that in this particular soil phosphate sorption is little affected by iron, but is almost entirely due to the aluminium.

NITROGEN AVAILABILITY

Seasonal changes in available nitrogen under pastures

J.R. Simpson

Factors affecting the status of available nitrogen in soils under specific pasture conditions are being examined. As fertility increases in pasture soils, as a result of continued superphosphate applications and clover growth, a stage is reached

when the amount of mineral-nitrogen in the surface soil begins to undergo pronounced seasonal changes, which result in distinct mineral-nitrogen accumulations during summer and autumn.

Studies have been continued into the soil and climatic factors involved which may bring about these fluctuations. The main accumulations occur within the top inch of the soil surface, but leaching may remove nitrate to 2 feet or more below the surface. The precise sequence of climatic events, particularly the period of drying between consecutive wettings by rainfall is of primary importance in nitrate accumulation since an important factor affecting the accumulation of nitrate under these pasture conditions has been shown to be the flush of microbial activity which follows the rewetting of previously dried soil. The period of drying, the frequency of rewetting and the intensity of leaching all interact in determining the level of nitrate accumulation and its distribution in the soil profile.

The extent of the fluctuations in available nitrogen was shown to be determined broadly by the total nitrogen content of the soil since no appreciable fluctuations were found in soils resown directly from native pasture with less than 0.10 per cent. N at 0-2 inches.

Release of available nutrients by drying and rewetting soil

J.R. Freney

It has been known for nearly 50 years that mineralization of nitrogen from soils is greater after the soil has been air-dried and rewetted than from soil which has not been allowed to dry. The mechanisms which cause this flush of mineralization are unknown, nor is it known which particular fractions of the soil nitrogen are involved in this mineralization.

The present study was initiated to investigate the nitrogen source which is released when undried and air-dried soils are incubated. At the same time information on the mechanisms of the reaction is being sought.

Initial results suggest that with some soil air-drying exposes part of the fixed ammonium which can then be converted to exchangeable ammonium and nitrate during the subsequent incubation.

SULPHUR AVAILABILITY

Sulphate sulphur in soils

C.H. Williams and A. Steinbergs

In the surface horizons of most well-drained soils the amounts of free water-soluble sulphates are generally small. However, insoluble sulphates and adsorbed sulphates may, in some soils, comprise an important fraction of the total soil sulphur.

In calcareous soils sulphate associated with the calcium carbonate has been shown to make an important contribution to the total sulphur. Further examination of this sulphate fraction has confirmed the possibility that it occurs as a co-precipitated or co-crystallized impurity in the calcium carbonate.

The importance of sulphate adsorption in relation to the sulphate content of soils has also been further examined. Most surface soils had only low capacity to adsorb sulphate and contained only small amounts of sulphur in the adsorbed form. Two surface soils and many acid subsoils, however, adsorbed sulphate quite strongly and in some acid subsoil clays, adsorbed sulphate accounted for a substantial portion of the total sulphur.

Sulphate adsorption was found to be negligible above pH 6.5. This adsorbed sulphate can be determined by aqueous extraction of soils after increasing the pH above this value by the addition of solid calcium carbonate. It was found that adsorption of sulphate during acid extraction of soils could lead to errors in the determination of acid-soluble sulphate. A second extraction with water after the addition of sufficient calcium carbonate to increase the pH to a value greater than 6.5 was found necessary to correct for this.

The determination of total sulphur in soils and plant material

A. Steinbergs, J.R. Freney, N.J. Barrow and O. Iismaa

Investigations have been concluded and a rapid, accurate method for the determination of total sulphur in soil or plant material has been developed. The method involves heating a suitable sample of the material with sodium bicarbonate and silver oxide in a small container (crucible or glass tube) at 550°C for 3 hours. Sulphate in the whole of the ignited material

is then determined by reduction to methylene blue.

Results of analyses by this method compare most favourably with those obtained by other published methods and the method is not subject to interference by barium. Thirty analyses may be completed per day.

SOIL FERTILITY

The interaction of wheat variety and soil fertility level

J. Lipsett

The use of clover leys in the wheat belt has led to higher soil fertility, and some confusion has arisen on the place in the system of wheat varieties hitherto grown. There is an absence of basic data on the composition and other characteristics of commercial wheat varieties when grown at higher levels of soil fertility.

Work designed to provide some of this information, particularly on factors determining the final phosphorus concentration in the grain, is in progress. This work is being carried out both in glasshouse and in field trials and involves both rates and timing of phosphorus applications.

Wheat at different fertility levels was subjected to droughting from the flowering stage onwards. Experimental production of "pinched" grain was achieved. Further work is being commenced to extend this trial and to confirm trends indicated in the earlier trial.

The characteristics of mottled grains which have occurred in these various experiments have been examined. The nutritional conditions under which mottling is affected have been studied for phosphorus, sulphur and copper levels.

SPECTROCHEMICAL INVESTIGATIONS

Atomic absorption method

D.J. David

Investigations of the application of the atomic absorption spectrophotometric technique to soil and plant analysis have been continued. Highly satisfactory methods for the determination

of sodium, potassium, calcium, magnesium, zinc, iron, manganese and molybdenum have now been developed and investigations have been completed into the use of this technique for the determination of strontium in plant material and exchangeable strontium in soils.

Calcium and phosphate together in solution seriously depress absorption of the strontium resonance line 4607Å although neither of these ions when present alone at the concentrations tested produce serious depression. Aluminium depresses strontium absorption seriously but its effect could be alleviated by the addition of excess calcium.

Except in the case of some acid soils adequate calcium was naturally present to suppress aluminium interference in the determination of exchangeable strontium. Thus, with these exceptions (when addition of calcium may be necessary) exchangeable strontium may be determined directly on the ammonium chloride extract without pretreatment. In some cases, however, accuracy can be considerably increased by removal of ammonium chloride and concentration of the solution.

For determination of strontium in plant material it was found desirable to remove phosphate. This can be achieved using an anion exchange column. Strontium can then be determined by atomic absorption flame spectrophotometric analysis using the "addition method".

Investigations have also been commenced into the determination of chromium in biological materials.

PUBLICATIONS

Cosgrove, D.J. (1962). - DL-inositol hexaphosphate in soils. Nature, Lond. (In press).

Cosgrove, D.J. (1962). - Scyllo-inositol hexaphosphate in soils. Nature, Lond. (In press)

David, D.J. (1961). - The determination of molybdenum by atomic absorption spectrophotometry. Analyst, Lond. 86:730-40.

David, D.J. (1962). - Emission and atomic absorption spectrochemical methods. "Modern Methods of Plant Analysis VI" (Springer Verlag: Heidelberg). (In press).

David, D.J. (1962). - The determination of strontium in biological materials and exchangeable strontium in soils by atomic absorption spectrophotometry. Analyst, Lond. 87: (In press).

David, D.J. (1962). - Atomic absorption spectrochemical analysis with particular reference to plant analysis. Rev. Uni. Ind. Santander. (In press).

Freney, J.R. (1961). - Some observations on the nature of organic sulphur compounds in soil. Aust. J. Agric. Res. 12: 424-32.

Freney, J.R. (1962). - The nature of sulphur compounds in soil and their conversion to forms available for plant growth. Ph.D. Thesis, Univ. of New England.

Freney, J.R., Barrow, N.J., and Spencer, K. (1962). - Sulphur in soil. A Review. Plant and Soil. (In press).

Lipsett, J. (1961). - The effect of cropping for wheat on the fertility of red brown earth soils in southern New South Wales, with particular reference to nitrogen and phosphorus status and competition for skeleton weed. M.Agr. Sc. Thesis, Univ. of Queensland.

Simpson, J.R. (1962). - Changes in available nitrogen in soils under pasture as influenced by soil microclimate and biological activity. Proc. Third Aust. Conf. in Soil Sci. 1: 87-1.

Simpson, J.R. (1962). - Nitrogen availability in soils under improved pasture in southern New South Wales. Aust. J. Agric. Res. (In press).

Steinbergs, A., Iismaa, O., Freney, J.R., and Barrow, N.J. (1962). The determination of total sulphur in soil and plant material. Analyt. Chim. Acta. (In press).

Williams, C.H., and Lipsett, J. (1961). - Fertility changes in soils cultivated for wheat in southern New South Wales. Aust. J. Agric. Res. 12: 612-29.

Williams, C.H., and Steinbergs, A. (1962). - The chemical nature of sulphate in some Australian soils. Plant and Soil. (In press).

Williams, C.H. (1962). - Changes in nutrient availability in Australian soils as a result of biological activity. J. Aust. Inst. Agric. Sci. (In press).

PLANT NUTRITION

Deficiency and imbalance of plant nutrients restrict pasture and crop production on most soils. Research in the Plant Nutrition Section is concerned with this problem. Glasshouse and laboratory studies aim to define, in biochemical and physiological terms, the role of nutrient elements in plant metabolism and the changes induced in plants by nutrient deficiencies. It is important to identify those effects which are a direct consequence of the metabolic function of the element in the plant and are specific for the element. Field and glasshouse studies measure deficiencies in terms of plant responses to specific elements and relate them to such things as chemical properties of the soil, the climatic environment, and fertilizer use and cropping history. The results of these investigations make it possible to define more precisely the nutrient deficiency or imbalance restricting production in different situations and so help in its effective correction.

Much of the work is concerned with pasture plants. An outstanding trend in Australia has been the increase in the use of fertilizer on pasture. Its importance in the Australian economy may be gauged from the fact that over the past decade the number of sheep in Australia has increased from about 110 million to 150 million and it has been estimated that about half of this increase can be attributed to the accompanying increase in the area of sown pasture.

Phosphorus studies

K.D. McLachlan, B.W. Norman and
P.G. Carruthers

Studies on the residual effects of phosphorus on pasture on the Southern Tablelands of New South Wales have shown that the need for current dressings of phosphorus may depend less upon the total amount that has been applied in previous years than upon the length of time since the superphosphate was applied. There is now strong evidence that a major factor governing the availability of residual phosphorus is the conversion of inorganic phosphorus to less available organic forms, probably through uptake by the plants themselves. The main fall in the residual value of phosphorus occurs after yield responses to phosphorus have been obtained. In accordance with this finding it has been shown that where the reserve of phosphorus in the

unimproved soil is low, and where yield responses to superphosphate are high, the residual effect of superphosphate falls rapidly with successive growing seasons. Where further dressings of superphosphate are not applied, yields on these deficient soils fall after a few seasons to approach those on untreated soils.

These findings on the significance of the plants in modifying the residual value of phosphorus for pasture can be expected to be important in the interpretation of the results of other experiments dealing with long-term effects of superphosphate on pasture. One of these experiments deals with the superphosphate requirements by pasture for the maintenance of levels of production under grazing. Associated with this study is a complementary experiment to determine the frequency of application of superphosphate needed to maintain pasture production where different amounts of superphosphate have been applied previously.

Marginal deficiencies in pasture plants

K. Spencer, D.V. Moye and D.R. Meyer

New problems requiring research in plant nutrition inevitably arise in areas where the gross deficiencies have been corrected in the initial stages of pasture development. There is a good deal of evidence that many existing improved pastures are already restricted in varying degree by marginal deficiencies of plant nutrients. In addition, the reported decline in vigour and density of clover in some areas may well be due to such deficiencies. Trials are being established to investigate the field distribution and characteristics of marginal deficiencies in Eastern Australia. Species with different nutrient requirements will be used in this study. Apart from their use in assessing the nutrient status of the soils, some of the species selected may prove to be useful in the area when their special nutrient requirements are met.

The cause of unthrifty lucerne at eight localities on the Southern Tablelands has been investigated in exploratory studies. Responses to boron were obtained at five sites, responses to molybdenum at two, and at one site a response to potassium was obtained. On the North Coast of New South Wales responses of lucerne to molybdenum were recorded, and symptoms of boron deficiency observed. Further trials are in progress to define the importance of boron deficiency in this and other lucerne-growing areas. It is clear from these preliminary trials and from observations made during a traverse of some lucerne-growing areas,

that boron deficiency is of some significance in much of the lucerne grown for hay in New South Wales. At present, a study of the diverse symptoms exhibited by lucerne deficient in boron in the field is being made. Interactions between boron and other nutrients are also being examined.

Investigations are also in progress to determine the possible significance of marginal deficiencies in areas where subterranean clover is reported to decline in vigour and density following the initial establishment of the pasture. Evidence with lucerne suggests that boron deficiency may be important in some of these areas.

Legume nodulation and nitrogen fixation

A.J. Anderson, J.V. Possingham, D.N. Munns and D.V. Moye

Under certain conditions nitrogen fixation in the nodules of legumes is restricted, resulting in nitrogen deficiency in the nodulated plants. This reduces the yield and protein content of the legumes and limits the effect of the legume in the build-up of soil fertility. Experiments in progress include a study of the inhibitory effect of temperature on symbiotic nitrogen fixation. Experiments designed to compare the separate effects of soil and air temperature suggest that it is the temperature of the roots, probably the nodules, and not the temperature of the plant tops that is involved. In these experiments pots containing clover plants were immersed in temperature controlled water baths, and the effects of air temperature on the temperature of the nodules was minimized by preventing the formation of nodules near the soil surface.

Present experiments aim to determine whether there are critical periods during which high soil temperatures are most harmful.

The uptake of elements by different plants

D.N. Munns

Both soil and plant factors are involved in problems of nutrient uptake. The importance of soil factors, for example the effect of soil pH on the availability of elements, is widely recognized. In addition, plants differ greatly in resistance to nutritional disorders and in response to fertilizer treatments, but little is known of the reason for these differences. Part

of this biological variation probably arises from differences in efficiency of utilization of particular nutrients within the plant. But plants also differ in relative rates of uptake and movement of nutrients. Investigation of suitable examples of biological variation could yield worthwhile information about mechanisms involved in uptake, transport, and utilization of nutrients. This approach also offers some hope of explaining why one plant succeeds where another fails, and of achieving better efficiency of extraction and use of nutrients by appropriate choice of species and variety. The ecological interest is obvious.

A comparison is being made of subterranean clover and lucerne in their behaviour on acid soils and their responses to liming. Lucerne could be a valuable pasture plant on the coast or tablelands but it is difficult to establish and maintain on the widespread acid soils. Varieties within lucerne are also being compared. These varieties differ significantly in winter production, and there is some evidence to suggest that their growth under cold conditions could be improved by better nutrition. Consequently the varieties are being compared not only in relation to soil acidity and response to lime, but also in relation to uptake of nutrients at low soil temperatures.

Factors affecting the uptake of strontium

J.V. Possingham and T.E. Treffry

A study is being made of factors affecting the uptake of strontium by plants. Much of the research that has been done on the contamination of plants by radioactive compounds has been concerned with the retention of fallout particles on leaf surfaces. The work on plant uptake of strontium is concerned with the long-term hazard whereby plants are contaminated from the reservoir of fission products built up in the soil.

As has been found in other countries, the uptake of strontium was greatest in soils containing low levels of exchangable calcium. The major increase in strontium uptake occurred over the narrow range of soil calcium levels associated with calcium deficiency symptoms in the plants. An effect of calcium on the uptake of strontium was obtained also in subsequent experiments with plants grown in water culture. Under conditions of calcium stress plants showed a significant growth response to the addition of strontium. This may be of importance in explaining the large uptake of strontium by calcium-deficient plants.

The physiological assessment of the nutrient status of plants

D. Bouma and E.J. Dowling

Attempts to identify the nutritional factors limiting pasture growth by chemical analysis of soil or plant tissue have not been greatly successful, except in a few isolated instances. Field experiments, and the recognition of visual symptoms are virtually the only reliable methods used at present to assess the need for nutrient applications.

Field experiments have a number of disadvantages. Responses to nutrient additions are usually slow, and only relatively gross differences are measured, which also adds greatly to the time factor. The current research aims at an earlier recognition of nutritional stresses in the plant. This has required a study of the removal of nutritional stresses more rapidly than is normally obtained in field experiments.

One approach to an earlier alleviation of nutritional stresses in plants may be found in foliar applications of nutrients in dilute solutions. This approach has been investigated for phosphorus. Subterranean clover plants were sprayed with solutions of different phosphorus compounds at several levels, with and without wetting agents. Growth, although better than that of plants without phosphorus, was considerably less than in the treatment in which phosphorus was applied to the roots. Different results may well be obtained for minor elements, and this will be investigated further.

A different approach to the early removal of nutritional stresses which has shown considerable promise, involves a study of the growth changes induced by transfer of deficient plants to a series of nutrient solutions each lacking a different element. Response curves were obtained for each of the elements P, S, K, Ca and B, by raising subterranean clover plants in water-cultures at five levels of these elements. The plants were then transferred to solutions with and without these elements, and the growth changes that occurred after transfer were followed over periods of seven days. It was found that the plants raised at deficiency levels showed considerably smaller increases in size if transferred to the solutions without the deficient element, than in the complete solutions or in those lacking other elements. By contrast, plants raised at adequate levels of these nutrients did not show such differences between the culture solutions. Growth changes after transfer were established by daily estimates

of leaf area on the same plants. By using this procedure it was possible to distinguish between deficient and non-deficient plants as early as two days after transfer.

The effect of nutrient deficiencies on chloroplast structure

J.V. Possingham, F.V. Mercer (Botany Dept., University of Sydney) and E. Rudczuk

Recent studies have shown that the nutritional status of higher plants has profound effects on their subcellular organization and structure. Observations using the techniques of phase contrast and fluorescence microscopy revealed that a deficiency of manganese leads to a greatly reduced number of chloroplasts in each cell and that within these chloroplasts the distribution of chlorophyll is quite abnormal. Electron micrographs prepared in collaboration with the Botany Department, University of Sydney, showed that in the chloroplasts of manganese-deficient plants the grana (chlorophyll containing structures) are increased in size and greatly reduced in number, while the intergrana lamellae are virtually absent. These observations are consistent with the marked depression manganese deficiency has on photosynthesis. Other large changes in chloroplast structure were found to be specifically associated with a deficiency of the element iron, while many deficiencies led to the formation of chloroplasts that were greatly reduced in size. Available evidence suggests that particular nutrient elements are important in the development of specific cell structures and in some cases are components of these structures.

Studies on chloroplast structure

D. Spencer and S.G. Wildman (University of California, Los Angeles, Fulbright Fellow 1961)

Chloroplasts, both in the living cell and in an isolated state, have been examined by phase contrast and fluorescence microscopy. Detailed observations have been made of the swelling patterns of isolated chloroplasts under controlled hypotonic conditions. The sequence of events during swelling of isolated chloroplasts has permitted some deductions to be made about the internal structure of the original chloroplast.

In the living cell the immobile chloroplast is surrounded by a jacket of mobile, amorphous material closely resembling mitrochondrial material in appearance and behaviour. This jacket,

which is often retained in the isolated state, can be seen to swell and burst when the sucrose concentration of the suspending medium is reduced from 0.4 to 0.2 M. At still lower concentrations a large number of individual swellings are seen at the margins and both surfaces of the chloroplast. This swelling pattern suggests that the jacket is the only all-encompassing structure around the chloroplast and that the chloroplast proper consists of a large number of individual osmotic units.

A model chloroplast has been constructed which aims to incorporate the above observations with the observations of other workers from electron micrography. The chloroplast is depicted as a stack of 25 separate, flat bags (stroma bags). Each bag is equivalent to the double lamella of electron micrograph sections. Structural continuity between the bags is provided by the columns of grana each of which traverse, and are fused to, a variable number of stroma bags. The jacket seen under phase contrast and the chloroplast membrane seen by electron microscopy are considered to be equivalent structures.

The correlation of structure and function in chloroplasts

D. Spencer and H. Unt

The chloroplast is a complex structure which carries out a large number of highly integrated biochemical reactions. It is of considerable interest to discover the structural requirements which are essential for various expressions of chloroplast activity, and in this way gain an understanding of the relationship between structural and biochemical organization within the chloroplast. Preliminary experiments have been started with this aim. The general approach is to bring about observable changes in the chloroplast structure by some means, such as osmotic swelling or mechanical fracture, and to determine the effect of these changes on a range of chloroplast reactions (Hill reaction, photophosphorylation, pyridine nucleotide reduction, CO_2 fixation).

The mechanism of action of Simazine

D. Spencer

Simazine, (2-chloro-4,6-bis(ethylamino)-1,3,5-triazine) is believed to exert its herbicidal effect by virtue of its ability to inhibit photosynthesis at low concentrations. Experiments were undertaken to localize more precisely the site of action of

simazine in the photosynthetic apparatus.

The action of simazine was tested on three different types of chloroplast reaction - the Hill reaction, and cyclic and non-cyclic photophosphorylation. It was found that low concentrations of simazine (10^{-5}M) strongly inhibited both the Hill reaction and non-cyclic photophosphorylation. Cyclic phosphorylation, on the other hand, was relatively resistant to simazine. Thus, simazine inhibits only those chloroplast reactions of which O_2 evolution is an integral part. This selective action indicates that the O_2-evolving sequence is the site of action of simazine at low concentrations.

PUBLICATIONS

Bouma, D., and Dowling, E.J. (1962). - The physiological assessment of the nutrient status of plants. I. Preliminary experiments with phosphorus. Aust. J. Agric. Res. 13: (In press).

Freney, J.R., Barrow, N.J., and Spencer, K. (1962). - Sulphur in soil. A Review. Plant and Soil. (In press).

Loneragan, J.F., Moye, D., and Anderson, A.J. (1961). - Survival of Rhizobium on clover seeds. Nature, Lond. 192: 526-7.

McLachlan, K.D. (1961). - Time of application of superphosphate and the yield of pasture on an acid soil. Aust. J. Exp. Agric. Anim. Husb. 1: 81-4.

McLachlan, K.D. (1962). - The nutrition of pasture plants. In "Studies in the Australian Wool Industry". Australian National University, University Press. (In press).

McLachlan, K.D., and Norman, B.W. (1961). - Phosphorus and symbiotic nitrogen fixation in subterranean clover. J. Aust. Inst. Agric. Sci. 27: 244-5.

McLachlan, K.D., and Norman, B.W. (1962). - Effects of previous superphosphate applications on the pasture environment and the response by pasture to a current dressing. Aust. J. Agric. Res. (In press).

Mercer, F.V., Nittem, M., and Possingham, J.V. (1962). - The effect of manganese deficiency on the structure of spinach chloroplasts. J. Cell. Biol. (In press).

Munns, D.N., Johnson, C.M., and Jacobson, L. (1962). - Uptake and distribution of manganese in oat plants. I. Varietal variation. Plant and Soil. (In press).

Munns, D.N., Jacobson, L., and Johnson, C.M. (1962). - Uptake and distribution of manganese in oat plants. II. A kinetic model. Plant and Soil. (In press).

Munns, D.N., Johnson, C.M., and Jacobson, L. (1962). - Uptake and distribution of manganese in oat plants. III. Analysis of some biotic and environmental effects. Plant and Soil. (In press).

Possingham, J.V., and Spencer, D. (1962). - Manganese as a functional component of chloroplasts. Aust. J. Biol. Sci. 15: 58-68.

Possingham, J.V. (1962). - Radioisotopes in Australian studies relating to plant nutrition and water stress. 10th Pacific Science Congress of the Pacific Science Association, Hawaii, 1961. Internat. J. Appl. Rad. and Isot. (In press).

Possingham, J.V., and Davis, P.S. (1962). - Fallout contamination in plants, In "Modern Methods in Plant Analysis" Vol. IV, Springer-Verlag, Germany. (In press).

Spencer, D., and Possingham, J.V. (1961). - The effect of manganese deficiency on photophosphorylation and the oxygen evolving sequence in spinach chloroplasts. Biochim. Biophys. Acta. 52: 379-81.

Spencer, D., and Wildman, S.G. (1962). - Observations on the structure of grana-containing chloroplasts and a proposed model of chloroplast structure. Aust. J. Biol. Sci. (In press).

Spencer, K. (1962). - The residual value of a sulphatic fertilizer applied to a basaltic soil. Aust. J. Exp. Agric. Anim. Husb. (In press).

Spencer, K., and Roe, R. (1962). - Agronomic studies on a Krasnozem in the Ebor District, New South Wales. C.S.I.R.O. Aust. Div. Pl. Ind. Rep. (In press).

BIOCHEMISTRY

Much of the work of this Section is related to research on aspects of the tetrapyrrole pigments, which include the chlorophylls, the haemoproteins, the haemins and the porphyrins. Current programmes in this region of biochemistry range from studies of proplastids and their development to plastids, and of the photosynthetically active chlorophyll-protein complex, through studies of the haemoproteins of nitrogen-fixing legume root nodules to studies of the biosynthesis of these pigments and of their physical and co-ordination chemistry. The physico-chemical studies have led to certain synthetic porphyrins with considerable antifungal activity.

Extensive studies of plant growth factors are being made in collaboration with members of the Plant Physiology Section and are described in the report of that Section. The structure of an antifungal substance, Pisatin, produced by pea plants in response to fungal infection, has been determined, and other antifungals of plant origin are being investigated (see report of the Microbiology Section).

Other topics under investigation include the metabolism of sulphur compounds by soil bacteria, the origin of sulphide minerals by microbial activity in sedimentary basins, and the occurrence of the perchlorate ion in natural materials, including higher plants.

The Fisons-Geigy Grant, of which details are given at the beginning of the Report, has permitted considerable expansion of the research on biologically active compounds.

STRUCTURE AND PROPERTIES OF PLANT PHOTORECEPTORS

Molecular weight of the protochlorophyll-protein complex

N.K. Boardman

A protochlorophyll-protein complex has been isolated from dark-grown bean leaves and purified by a number of protein fractionation procedures; details of the methods have been given in previous Annual Reports. The purification was followed by spectrophotometric and ultracentrifugal analyses and it was

concluded that the protochlorophyll was associated with a protein boundary with a sedimentation coefficient of 18S.

The molecular weight of the complex was calculated from measurements of sedimentation coefficient, diffusion coefficient and partial specific volume. The sedimentation coefficient was determined over a range of protein concentrations and the value at zero protein concentration obtained by extrapolation. Diffusion measurements were carried out in the synthetic boundary cell of a Spinco Model E ultracentrifuge. The following values were obtained:- sedimentation coefficient ($S_{20,w}$) 18.0×10^{-13} sec, partial specific volume 0.73 ml/gm. and diffusion coefficient ($D_{20,w}$) 2.70×10^{-7} cm^2/sec. From these figures the molecular weight of the protochlorophyll-protein complex was calculated as 600,000 $\pm$ 50,000. Determination of the protochlorophyll content of the complex indicated that the most purified preparations contained on the average one protochlorophyll molecule per protein molecule.

Both shadowed and negative-stained preparations of the complex were examined in a Siemens electron microscope. The resulting electron micrographs showed a spherical molecule with a particle diameter of 100-110 Å.

Conversion of protochlorophyll to chlorophyll a

N.K. Boardman and Mrs. S. Sapiets

The photo-reduction of protochlorophyll to chlorophyll a in the isolated and partly purified protochlorophyll-protein complex was studied kinetically over a range of temperatures from -55° to +25°. To explain the kinetic data, it is postulated that protochlorophyll molecules are bound to the protein in two different ways. Equations were derived on the assumption that both forms of protochlorophyll are transformed to chlorophyll a by first order reactions, but at different rates. Rate constants were calculated by fitting the derived equations to the experimental curves and activation energies were obtained from the rate constants. Activation energies obtained for the conversion of one form of protochlorophyll were low compared with those usually found for an enzymically-activated collision process, although those obtained for the conversion of the second form of protochlorophyll were within the range found with enzymic reactions.

The conversion of protochlorophyll is explained as a restricted collision process within the protochlorophyll-protein

complex. The protochlorophyll and the hydrogen or electron donor both appear to be an integral part of the complex and it is postulated that they may be located in an hydrophobic region of the complex.

Isolation, identification and photochemical activity of proplastids

N.K. Boardman, S.G. Wildman (Fulbright Fellow) and Joan M. Anderson.

When dark-grown bean leaves are sectioned and the living cells examined by fluorescence and phase-contrast microscopy, chlorophyll-containing structures (proplastids) which are about one-third to one-half the size of chloroplasts are observed. Using fluorescence microscopy as a means of identification it was found that a proportion of the proplastids would survive homogenization of the tissue in 0.4M sucrose, sedimentation into a pellet and purification by centrifugation in a sucrose gradient column. Two sharp intensely yellow bands were obtained at positions in the sucrose column corresponding to densities of 1.13 and 1.24. Microscopic examination showed that the lower band contained only intact proplastids, apparently completely free of other organelles that are present in the etiolated leaves; the upper band contained both proplastids and fragments.

Examination of the purified proplastids by fluorescence and phase-contrast microscopy revealed that the protochlorophyll is confined to small discrete bodies 0.7 - 1.3 μ in diameter and located at random within a transparent bag, 3-5 μ in diameter. Up to 4 or 5 fluorescent bodies have been observed in a single proplastid.

Preliminary studies on the changes in proplastid structure following illumination of dark-grown plants suggest that the protochlorophyll structures of the proplastid persist even after extensive deposition of chlorophyll into grana has occurred in those parts of the proplastid bag which were originally transparent.

Concurrently, studies on the development of photochemical activity during chloroplast development are being carried out; plastids isolated from etiolated bean leaves and from plants which have been illuminated for varying periods are being assayed for a number of photochemical activities.

STUDIES OF PORPHYRIN AND HAEM PIGMENTS

Coproporphyrinogen oxidative decarboxylase

R.J. Porra and J.E. Falk

This enzyme is responsible for the conversion of two propionic acid side-chains of coproporphyrinogen III to the vinyl side-chains found in protoporphyrin. As reported previously, protoporphyrinogen is formed in this aerobic reaction and is subsequently oxidized to protoporphyrin.

Further studies of the enzyme, extracted from acetone-dried liver mitochondria by phosphate buffer, have shown that none of the cofactors biotin, thiamine pyrrophosphate, coenzyme A or pyridoxal phosphate is required for its activity.

The enzyme has been found to utilize as substrate coproporphyrinogen III, the natural isomer, and also the "unnatural" isomer IV, but not isomers I and II. Like uroporphyrinogen decarboxylase, the present enzyme requires reduced porphyrins as substrate, and will not react with coproporphyrins.

Ferrochelatase

R.J. Porra and O.T.G. Jones

This enzyme system, responsible for the insertion of Fe^{++} ions into protoporphyrin, has been prepared in soluble form from liver mitochondria.

Though aerobic conditions are necessary for the formation of protoporphyrinogen (see above) and for its oxidation to protoporphyrin, the subsequent enzymic insertion of iron by the mitochondrial extract is inhibited completely by oxygen. Under anaerobic conditions high rates of incorporation were found, measurements being made by the use of ^{59}Fe and by direct spectrophotometric determination of the haems formed as their pyridine haemochromes. Pre-incubation with glutathione makes no difference to the activity of the mitochondrial enzyme system; it is required if Fe^{+++} ions are used, but not if the iron is added in the Fe^{++} state. The inhibition by oxygen may thus be due either to autoxidation of Fe^{++} or to interference with an intermediate step in the coordination of the metal. There is no evidence to suggest that it is due to inactivation of an enzyme.

The mitochondrial enzyme system does not catalyze the incorporation of iron into porphyrinogens. It utilizes the

following porphyrins, in descending order: deutero, meso IX, meso I, haemato, monoformyldeutero, monohydroxymethyldeutero, monovinyl-mono(β)-hydroxyethyldeutero, proto and chlorocruoro. The relatively poor utilization, under the conditions of comparison (pH 7.8) of the natural substrate, protoporphyrin, is noteworthy; it is possible (see below) that several enzymes with different specificities may be present. Porphyrin a and the alcohol obtained by reduction of its formyl group, 2:4-diformyldeuteroporphyrin, coproporphyrin, porphyrin c and pyrroporphyrin XV were not utilized.

Many of the porphyrins studied are relatively insoluble in neutral aqueous media, and most were studied in the presence of the detergent Emasol 4130. With the mitochondrial enzyme preparation, a peak of activity was found at pH 7.8 for both proto- and meso-porphyrins. A second peak was found at pH 9; in the case of protoporphyrin this was even larger than the peak at pH 7.8. The possibility that this was due to changes with pH of solubility or of non-enzymic iron incorporation was excluded, and it appears possible that more than one enzyme with ferrochelatase activity may be present.

Active soluble enzyme preparations were obtained from bakers' yeast, E. coli, Thiobacillus X and Chromatium D, and some differences in substrate specificity were found between these and the mitochondrial preparation. Extracts from Cl. Welchii, in which the presence of cytochromes has not been demonstrated, had no ferrochelatase activity.

The effect of chelators on metalloporphyrin formation

O.T.G. Jones

It has been suggested that the chemotherapeutic action of certain chelating agents (e.g. 8-hydroxyquinoline, diethyl dithiocarbamate, kojic acid) may be explained by their property of catalysing the insertion of metals into porphyrins (Lowe and Phillips, 1962). Enzymic and non-enzymic mechanisms for the formation of metal-porphyrin complexes have been studied to gain more information about the feasibility of this hypothesis.

It was found that ferrochelatase (see above) was only slightly affected by levels of Cu-diethyldithiocarbamate which are fungicidal and that dilute protein solutions (1 mg/ml) greatly reduce the non-enzymic incorporation of Cu into mesoporphyrin, even in the presence of chelating agents.

The biosynthesis of haem from glycine and ^{59}Fe by chicken erythrocytes was inhibited by 8-hydroxyquinoline, which also reduced ^{59}Fe incorporation into protoporphyrin by ferrochelatase extracts. 8-hydroxyquinoline did not catalyse any significant incorporation of ^{60}Co into porphyrins under physiological conditions and chicken blood preparations did not catalyse any enzymic incorporation of ^{60}Co.

Respiration enzymes and haemoproteins of the legume root nodule

C.A. Appleby

Leghaemoglobin appears to play an essential role in the symbiotic fixation of nitrogen by legume root nodules. As was reported previously, artificially-reduced leghaemoglobin appears to form a complex with gaseous nitrogen. If such a reaction occurs in the root nodule, reduction of the leghaemoglobin is likely to be due to respiratory enzymes of the bacteroids, the form in which the Rhizobia exist inside effective nodules. The properties of these enzymes have been investigated further.

With succinate as substrate, the respiration of both bacteroids and the free-living Rhizobium was partly inhibited by carbon monoxide in the dark. This inhibition was reversed by light only in free-living Rhizobium, confirming the spectroscopic identification of classical cytochrome oxidase (cytochrome a_3) in these organisms and its absence from bacteroids. Another carbon monoxide-reactive, but light-insensitive haemoprotein, previously isolated from bacteroids, probably functions as an oxidase during their respiration on succinate.

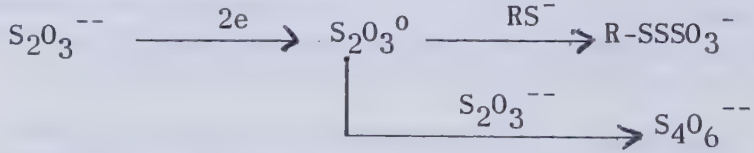
Both bacteroids and free-living Rhizobia have a vigorous endogenous respiration which is not diminished by repeated washings of the organisms, and is probably due to poly-β-hydroxybutyric acid, which has been isolated in high yield from both forms of the microorganism. This endogenous respiration is completely insensitive to carbon monoxide, suggesting that a different terminal oxidase is involved in the respiration of poly-β-hydroxybutyric acid or other endogenous substrates. Since the endogenous respiration is inhibited completely by cyanide and partly by ethylenediamine tetraacetate, this oxidase is probably a metalloprotein. It is feasible that one of the two oxidase systems which have been demonstrated in the bacteroids may act as a preferential electron donor to oxidized or oxygenated leghaemoglobin, rather than to molecular oxygen.

Oxidation of thiosulphate and tetrathionate by Thiobacilli

P.A. Trudinger

The effects of experimental conditions upon the oxidation of thiosulphate and tetrathionate have been studied further over the past year. The oxidation of tetrathionate is completely inhibited by -SH reagents such as N-ethyl maleimide and p-chloromercuribenzoate and by high oxygen tension. These same reagents block the oxidation of thiosulphate at the tetrathionate stage. Conditions can however be so arranged that tetrathionate oxidation is blocked but thiosulphate oxidation proceeds rapidly to completion. This raises doubt as to whether free tetrathionate is an intermediate in the oxidation of thiosulphate. Nevertheless studies with labelled (S) thiosulphate have shown that in the early stages of the reaction sulphate arises from the outer (S) and inner (SO_3) sulphur atoms of thiosulphate in a ratio of 1:2, indicating that two thiosulphate molecules take part at some stage of the oxidation sequence. On the basis of these and other results a reaction sequence which involves the intermediate formation of organic sulphenyl derivatives of thiosulphate etc. has been proposed as a working hypothesis.

In this scheme it is proposed that the primary reaction of the thiosulphate - oxidizing enzyme is the removal of two electrons from one thiosulphate molecule to form an enzyme - substrate complex $[S_2O_3^{o}]$, which then reacts with a thiol to form an organic sulphenyl derivative.



The nature of the thiol is at present unknown; it may well be an active enzyme centre. Tetrathionate becomes a side product formed only when the supply of $R\text{-}S^-$ is blocked by SH reagents or O_2. The reaction of $[S_2O_3^{o}]$ entities with <u>both</u> SH groups of a thiol is proposed to explain the 1:2 relationship of sulphate formation from the outer and inner sulphurs of thiosulphate.

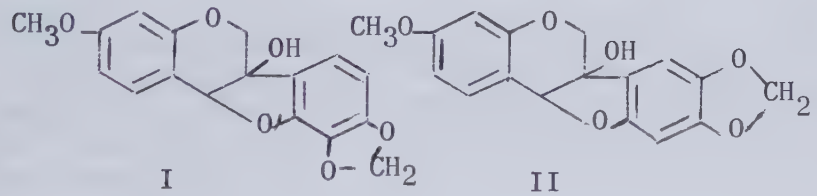
This scheme can account for all the data so far observed for thiosulphate and tetrathionate oxidation and also for the hitherto puzzling results of anaerobic tetrathionate metabolism.

Pisatin - an antifungal substance

W. Bottomley and Dawn R. Perrin (Microbiology Section)

Pisatin is produced by Pisum sativum in response to fungal infection, and is responsible for the non-pathogenicity towards peas of those fungi which are not pisatin-resistant.

As was reported previously, pisatin has been isolated, and was shown to be 3-hydroxypterocarpin, to which structure I was assigned. Subsequent comparison of anhydropisatin with methyl anhydrosophorol has shown that these two compounds are identical. In methyl anhydrosophorol, the methylenedioxy group is known to be in the 3':4'-position, not the 2':3'-position as shown in I. The structure previously assigned to pterocarpin has now, indeed, been revised and pisatin is in fact 3-hydroxy-pterocarpin, as previously claimed, but with the revised structure II.



I II

Treatment with ultra-violet light converts pisatin to an iso-flavylium salt; attempts to isolate an intermediate isoflavandiol in this reaction have been unsuccessful, apparently because of the instability of the diol. This indicates that isoflavan-3:4-diols may be considerably less stable than the related flavan-3:4-diols (leucoanthocyanidins) which occur in nature.

THE BIOGENESIS OF SULPHIDE MINERALS

The bacterial formation of sulphides

K.L. Temple

Sulphate-reducing bacteria from a marine estuary were incubated in media containing heavy metal compounds of low solubility. The following biogenic sulphides were identified by x-ray diffraction: PbS from basic lead carbonate, ZnS from zinc

carbonate and a copper sulphide (Cu S, CuS_2 or a mixture thereof) from copper carbonate.

Compounds of nickel, bismuth, antimony, arsenic, tin and cobalt underwent colour changes consistent with sulphide formation but did not yield crystalline sulphides identifiable by x-ray. None of the compounds prevented growth of the bacteria.

Covellite, Cu S, was formed in a copper sulphate solution suspended over a culture of sulphate-reducing bacteria.

Cultivation of marine sulphate-reducing bacteria in the presence of copper sulphate resulted in increased tolerance toward soluble copper. A sulphate-reducing culture obtained from a salt lake receiving leach water from copper tailings had still higher copper tolerance.

Organic materials in pyritic shales

K.W. Loach

From the Precambrian pyritic shales of Mt. Isa, materials were isolated which have been claimed by other workers to be organic micro-fossils. The pyrite in these shales may be syngenetic, due to biochemical activity in the sediments, or may be of magmatic hydro-thermal origin by secondary replacement. It is hoped that study of the fossil organic contents of these pyritic shales may provide evidence of their mode of formation.

The identification of perchlorate in natural materials

K.W. Loach

The occurrence of perchlorate in natural materials reported previously, was checked by an improved procedure. A new method of concentrating and isolating perchlorate utilizing Dowex resin chromatography was developed, and quantitative recoveries were found in control experiments. Perchlorate was determined by the specific infra-red absorption of the complex formed on treatment with potassium perrhenate and tetraphenyl arsonium chloride.

By these methods, perchlorate was found in cabbage and silver beet leaves at levels of approximately 10 µg/kg fresh weight and in urine at 20 to 30 µg/l. Perchlorate was not found in sea-water or in natural salt deposits from Australian salt

lakes.

Since perchlorate, though its activation energy is high, is a strong oxidizing agent, it seemed possible that with enzymic or photochemical activation it might act as a Hill oxidant in photosynthetic systems. In experiments with isolated silver beet chloroplasts, perchlorate did not function as a Hill oxidant.

Experiments are underway to study, by isotopic labelling techniques, the origin of the perchlorate in plant tissue.

STUDIES OF ALGAL CELL MEMBRANES

Fluxes of bromide ions in frog muscle cells

N.A. Walker and N.C. Spurway (Physiological Laboratory, Cambridge)

Previous work by Hodgkin and Horowicz had suggested that for the frog muscle cell there was a discrepancy between the chloride conductances as calculated from electrical measurements and from flux measurements. This discrepancy might be explained by the movement of chloride ions through the membrane in long narrow channels, as was proposed by Hodgkin and Huxley for potassium ions in 1954.

The "narrow channel" hypothesis was tested using frog sartorious muscle, which is particularly suitable because the passive anion permeability does not vary with the membrane potential. Bromide was used instead of chloride to take advantage of the more suitable radioactive isotope, ^{82}Br. The efflux of bromide from a muscle equilibrated with labelled bromide ions was measured, with constant membrane potential and internal bromide concentration, but with the three external bromide concentrations: 0, 30 and 120 mM. No evidence was found to support the "narrow channel" hypothesis; the results suggest, on the contrary, an exchange diffusion component of about one-tenth of the internal bromide.

In the course of this work it was found that there is interaction between the anions Cl^-, Br^-, I^-, NO^-_3, (written in order of decreasing permeability); a less permeable ion outside the cell inhibits the efflux of a more permeable ion, and a more permeable ion outside increases the efflux of a less permeable ion. These results also speak against the "narrow channel" hypothesis.

An effect of light on the plasmalemma of Chara cells

N.A. Walker

It was found that under some conditions illumination of Chara cells produced striking changes in the electrical properties of the plasmalemma. While under the experimental conditions used by most workers in the past illumination had little effect, under suitable conditions light increases the magnitude of the membrane potential difference and greatly reduces the membrane resistance (the latter typically from 30 to 4 cm^2). The necessary conditions were found to be the presence of calcium and bicarbonate ions in the medium bathing the cell; other common ions had no influence on the effect. Thus the effect occurs under natural conditions (presence of calcium and high pH) in which these plants grow well.

The action spectrum for the effect was found to be very similar to the action spectrum for photosynthesis in green algae: it has a minimum near 5400Å and a sharp cut-off near 7000Å. Two substances which specifically inhibit photosynthesis, C.M.U. and simazin, were found to inhibit this effect at concentrations of 10^{-5}M. Thus the effect is produced by light absorbed by the photosynthetic pigments, and is dependent upon at least some of the chemical reactions of photosynthesis.

The ionic requirements suggest a connexion with the phenomena of bicarbonate uptake during photosynthesis: the resistance change is ascribed to the increase in permeability of the membrane to an ion or ions, possibly bicarbonate.

This appears to be the first demonstration of a large effect of light on membrane resistance: its discovery opens up a biophysical approach to a region of wide interest in plant physiology. Some aspects of the effect which are being investigated include its ionic mechanisms, and the mechanism connecting light absorption in the chloroplast with the permeability of the cell membrane. The effect is also of interest as an example of the metabolic control of a passive diffusion process.

Instrumentation

S.W. Thorne, B.H. Wall, C. de Plater

The following projects have been completed during the year:

Modification of an "Optika" recording spectrophotometer: (i) Automatic temperature control over the range 25-80°C to an accuracy of ± 0.1°C was applied to both the sample and reference 5 cm cuvettes; (ii) a new reversible motor provided wavelength scan rates of 60, 30, 10, 5 and 3 Å/sec. Time constants in the signal circuits were modified and reduced; (iii) the addition of automatic scanning and recording equipment provided scanning over any selected wavelength range within the limits 190 mμ to 1000mμ. At completion, the recording is stopped and the wavelength drum is returned to its initial setting. After a selected delay time of 0, 5, 10, 30 or 60 minutes or 1, 2, 4 or 8 hours a new automatic scan occurs; (iv) the range of the red/infra red photomultiplier is restricted to 200-700 mμ with the 1P28 photomultiplier and is extended to cover the range 350-1000 mμ using a red sensitive photomultiplier. This enables automatic recordings to be made up to 1000 mμ with full photomultiplier sensitivity; (v) a pH titrator (pH stat) has been developed to operate with a 5 cm cuvette. The pH range is from 1 to 10 units, with a selected sensitivity of ± 1.0, ± 0.3, ± 0.1, ± 0.03, ± 0.01 pH unit. Up scale and down scale circuits are provided with automatic changeover. Liquid feed rates vary over a range 100:1 as balance is approached. Motor-driven microsyringes allow liquid to be measured to ± 0.0002 ml.

Temperature integrator:- A temperature integrator has been developed, to record the time for which a thermistor sensing element remains above (or below) a fixed temperature. The fixed temperature point may be preset within the range 0-35°C to ± 0.5°C. The instrument is designed for use in the field, and will operate for up to four months on a single torch cell.

Direct-reading differential thermometer:- A direct-reading differential thermometer with a difference range of up to 5°C and accuracy ± 0.1°C, over an absolute temperature range of 0-35°C, has been developed. The instrument is portable; platinum resistance elements are used in conjunction with electronic circuitry.

Electrical properties of metalloporphyrins

S.W. Thorne, B.H. Wall and C. de Plater

Electrical measurements on a series of metal-tetrapyrrole complexes are being made. Some of these organic compounds exhibit semi-conducting properties and are being studied to provide information on electron energy levels within the solid structure. The resistivities follow the general law

$R = R_0 \exp. (\Delta E/2kT)$, with ΔE, the "energy gap", ranging from 0.9eV to 3.2eV in different compounds. Photoconductive effects in these compounds are also being investigated.

PUBLICATIONS

Appleby, C.A. (1962). - The oxygen equilibrium of leghaemoglobin. Biochim. Biophys. Acta. (In press).

Boardman, N.K. (1962). - Studies on a protochlorophyll-protein complex. I. Purification and molecular weight determination. Biochim. Biophys. Acta. (In press).

Boardman, N.K. (1962). - Studies on a protochlorophyll-protein complex. II. The photo-conversion of protochlorophyll to chlorophyll a in the isolated complex. Biochim. Biophys. Acta. (In press).

Boardman, N.K., and Wildman, S.G. (1962). - Identification of proplastids by fluorescence microscopy and their isolation and purification. Biochim. Biophys. Acta. (In press).

Falk, J.E. (1962). - The chemistry and biochemistry of porphyrins and metalloporphyrins. "Comprehensive Biochemistry" (Elsevier: Amsterdam). (In press).

Falk, J.E., and Phillips, J.N. (1962). - Physical and co-ordination chemistry of the tetrapyrrole pigments. In "Chelating Agents and Metal Chelates". (Ed. Mellor and Dwyer, Academic Press, N.Y.). (In press).

Goldacre, P.L., and Unt, H. (1961). - The cultivation of isolated roots of subterranean clover and some effects of amino acids on their growth pattern. Aust. J. Biol. Sci. 14: 323-35.

Goldacre, P.L., Unt, H., and Kefford, N.P. (1962). - Cultivation of isolated tissue derived from the pericycle of roots. Nature, Lond. (In press).

Greenham, C.G. (1962). - Studies on translocation of herbicides in skeleton weed (Chondrilla juncea L.). Aust. J. Agric. Res. 13: (In press).

Kefford, N.P., and Goldacre, P.L. (1961). - The changing concept of auxin. Amer. J. Bot. 48: 643-50.

Loach, K.W. (1961). - Spot plate procedure for detection of volatile substances; detection of bromide. Chem. Analyst 50: 105-6.

Loach, K.W. (1961). - Detection of nitrate on paper chromatograms with a corrosive reagent. J. Chromatog. 6: 367-8.

Lowe, M.B., and Phillips, J.N. (1962). - A possible mode of action of some antifungal and antibacterial chelating agents. Nature, Lond. (In press).

Perrin, Dawn R., and Bottomley, W. (1961). - Pisatin, an antifungal substance from Pisum sativum L. Nature, Lond. 191: 76-7.

Perrin, Dawn R., and Bottomley, W. (1962). - Studies on phytoalexins. V. The structure of pisatin, a phytoalexin from Pisum sativum L. J. Amer. Chem. Soc. (In press).

Phillips, J.N. (1961). - Physicochemical properties of porphyrins In "Comprehensive Biochemistry" (Elsevier: Amsterdam). (In press).

Porra, R.J., and Falk, J.E. (1961). - Protein-bound porphyrins associated with protoporphyrin biosynthesis. Biochim. Biophys. Res. Commun. 5: 179-84.

Thorne, S.W. (1960). - A temperature-control system for use with a spectrophotometer. J. Sci. Instrum. 37: 478-80.

Thorne, S.W. (1962). - A precision automatic pH titration apparatus for use with a spectrophotometer. J. Sci. Instrum. (In press).

Vishniac, W., and Trudinger, P.A. (1962). - Carbon dioxide fixation and substrate oxidation in the chemosynthetic sulphur and hydrogen bacteria. Bact. Revs. (In press).

PLANT PHYSIOLOGY

Work has continued in three broad fields. One group has investigated aspects of development and morphogenesis at the whole plant level; a second group is concerned with biochemical differentiation, and thus provides a valuable link between classical plant physiology and biochemistry. The third group is concerned with the isolation and characterization of plant growth regulators, and studies of their biological functions.

In addition, work has been initiated on the physiology of pasture growth. From this it is hoped to increase our understanding of the determinants of yield.

Effects of growth substances and antimetabolites on inflorescence initiation in Lolium temulentum

L.T. Evans

The objective of this work is to gain information on the substances participating in the photoperiodic processes in the leaves and in the inductive processes at the shoot apex. The approach adopted is to apply possible participating substances and their antagonists to various sites and at various times during induction.

Gibberellins:- Single injections of 3 µg gibberellic acid induce inflorescence development under short day conditions, and accelerate it in plants exposed to one long day, to an extent depending on the time of application. This promotive effect is reduced when the leaves are held in nitrogen. It seems, however, that GA influences inductionthrough neither of the known environmentally controlled processes occurring in the leaves of L. temulentum. Neither CCC nor Amo-1618, two substances that have been considered as antigibberellins, reduce the effects of GA applications.

Auxins:- For plants exposed to one long day the auxins NAA and IAA tend to inhibit inflorescence initiation, particularly when applied during the one long day exposure. On the other hand, when plants are held in short days, auxin application combined with a light flash given in the middle of the dark period leads to inflorescence initiation in about half of the plants, although neither auxin nor light flash alone gave any initiation.

Leaf sensitivity to induction in Rottboellia exaltata

L.T. Evans

It has previously been shown that the presence of lower leaves in long days while the uppermost are undergoing short day induction can be highly inhibitory to inflorescence initiation. More surprising was the finding that the lower leaves reduce the flowering response even when held in short days, though to a lesser extent than they do in long days. Maximum response is obtained when only the emerging uppermost leaf is exposed to short days. The youngest fully expanded leaf alone can induce flowering when exposed to short days, yet, in the presence of the emerging leaf, it reduces the response to the latter.

Rottboellia thus resembles Xanthium in that it is the expanding leaf which is most sensitive to photoperiodic induction, but differs sharply from it in the inhibitory effect of the older leaves.

Effect of daylength on shoot initiation in Rambler lucerne

J. Ludwig

It was previously found that shoot initiation in one clone of Rambler lucerne was restricted almost entirely to short days. Field evidence suggested that such a response might not be general in Rambler, so the effect of daylength on 12 clones from a Canadian population and 12 from an Australian population, ranging in habit from creeping and non-creeping sativa types to creeping and non-creeping falcata types, was examined at a temperature of $22^{o}/15^{o}C$.

It was found that all plants which were creeping in the field produced adventitious shoots from their roots within the 13 weeks experimental period, while some non-creepers in the field also produced shoots. In most genotypes daylength had little effect on adventitious shoot production. One clone showing little creep in the field produced many adventitious shoots in the 16 hours photoperiod, but scarcely any in 8 hour days. Another creeping clone produced shoots only in short days.

Growth of the adventitious buds following their initiation was also relatively independent of daylength, though favoured by short days in some clones, by long days in others.

A relationship between dormancy and some physical characters of subterranean clover seed

L.A.T. Ballard and A.E. Grant Lipp

This study was undertaken as an aid to the interpretation of the seasonal variations in the level or intensity of dormancy observed in subterranean clover seeds. At least part of this might be expected to arise through variations in environmental conditions.

Initially the question was asked, "Is a whole seed population uniform in germination behaviour, or can it be partitioned into classes with different and characteristic performances?".

Seeds were obtained from the burrs of field-grown Mount Barker, Burnerang, and Portugal plants, by machine (rubber blades) threshing, and by finger separation. Each sample was sieved to retain approximately the largest and smallest one-third of the population. These fractions were well separated, "large" seedsweighing about twice the corresponding "small" seeds. Each fraction was again quantitatively partitioned into soft seeds, and hard seeds which were then softened by scarification. These 4 classes were tested at intervals for germination under control conditions and under CO_2-stimulation.

The following main results emerge: (i) "small" seeds have a larger proportion of naturally soft seeds than "large" seeds; (ii) "large" seeds are less dormant than "small" seeds, i.e. they germinate more, earlier in post-harvest life, or, under CO_2-stimulation, achieve maximum germination earlier in a test; (iii) soft seeds are less dormant than hard seeds; and (iv) machine threshing effects considerable softening, and it preferentially softens "large" seeds.

If it were subsequently shown (and we have preliminary data favouring this notion) that seed size may be accepted as an index of time of seed formation, this would support the belief that the environment obtaining during seed maturation has definitive effects on germination characteristics.

Quantitative aspects of CO_2-induced germination in subterranean clover

L.A.T. Ballard and A.E. Grant Lipp

We have previously shown that seed dormancy in subterranean clover may be relieved by exposure of imbibed seeds to

CO_2. Some quantitative aspects are described.

Replicate batches of the residual dormant seeds remaining after holding imbibed seeds of the Introduction Portugal 19465 at 22°C for 6 days were exposed to 2.5 and 40 per cent. CO_2 for 3, 6, 9 and 24 hours respectively, and then returned to air.

Complete germination was obtained at both concentrations for 24 hours exposure; but for shorter exposures the higher concentration always induced more germinations. The exposure times required for 50 per cent. germination, under these conditions, were 3.0 and 6.6 hours for 40 and 2.5 per cent. CO_2 respectively.

An interesting feature of the results is the fact that, for all exposure times and concentrations, the elicited germination was completed by 24 hours after the commencement of CO_2 exposure. This, together with the fact that exposure to 40 per cent. CO_2 for a period as brief as 0.5 hours (10 per cent. germination) yields practicable amounts of tissue for assay purposes, has made feasible a search, using $C^{14}O_2$ techniques, for the early-formed carbon compounds assumed to be effective.

Initiation of morphogenetic patterns

A.H.G.C. Rijven

An attempt has been made to find evidence for the validity of a fundamental assumption in Turing's model for morphogenesis, that the inception of the patterns in early morphogenesis is random in orientation.

Randomness was looked for at 3 levels:- (i) in the establishment of bilateral symmetry in a radially symmetrical embryo. Evidence in favour of this point was deduced from random orientation of cotyledons of torpedo-shaped embryos in cross-sections of seeds of Anagallis; (ii) in the establishment of dorsiventrality in the now bilaterally symmetrical embryo. Evidence in favour of this point emerged from frequency distribution patterns of "inside" and "outside" position of the first leaf in some small seeded legumes, e.g. subterranean clover; and (iii) in the establishment of left-right asymmetry (helical direction) in the now dorsiventral embryo. Evidence in favour of this point emerged from a study of the frequency distribution of 3rd leaf position in subterranean clover.

Leaflet movements of Mimosa pudica

C.N. Williams

The diurnal leaflet movements of M. pudica have been studied using time-lapse photography. Detached leaflet pairs show diurnal opening and closing movements similar to attached leaflets. The movements are motivated by changing turgor of certain cells within the pulvinus. Plant growth regulators such as IAA and gibberellin stimulate the opening movement (increase the turgor of the pulvinal cells). The movements are repeatedly reversible so that the increased turgor under the action of plant growth regulators cannot occur through effects on cell wall plasticity, which suggests effects on permeability and osmotic potential.

Previous studies with other tissues have shown that auxins do not increase the osmotic potential of plant sap as a whole. It is suggested that the action here may be to affect the distribution of solutes about the cell tonoplast or between the plasma membrane and the intercellular spaces.

Amino oxidase level and growth in decotylized pea embryos cultured on different media

A.H.G.C. Rijven

It was attempted to find out by means of embryo culture whether, as in cases of "induction" or "repression", the level of potential enzyme activity in the pea can be controlled by the presence of substrates and other metabolites.

Amino oxidase (AO) level is reported by Kenton and Mann, 1952, to be very low in germinating pea seeds, to rise quickly to a maximum at the age of 12 days and then to decrease rapidly. Observations of Werle and Pechmann, 1949, on Bacterium pyocyaneum suggest that synthesis of the enzyme may be induced by the presence of substrate.

In this study pea embryos, decotylized 24 hours after soaking of seed, were explanted on agar medium, containing 4 per cent. sucrose and salts, but no combined nitrogen except as specified in the treatments. After several time intervals (3, 4, 5 days) the plants were harvested and extracts prepared from them. Standard assays showed that the pretreatment with 1-5-diaminopentane (1-5 dp), applied 0.4-2.0mM, decreased apparent activity

per embryo to 45 per cent. of the control pretreatment. This peculiar phenomenon, resembling neither induction nor repression, probably reflects an *in vivo* condition: intact control plants respired exogenous 1-5 diaminopentane considerably faster than plants pretreated with this diamine.

The phenomenon is specific for AO; pretreatment with 1-5 dp did not affect the level of ascorbic acid oxidase, another Cu containing oxidase. Decreased AO activities were also observed with 1-4 diamino - butane and with L-Lysine, both substrates, but there was no decrease with L-alanine, not a substrate; quite remarkably neither was there an increase with L-alanine even though it stimulated protein synthesis markedly. In general, AO level became constant after 3 days, even though growth proceeded steadily thereafter. So far only raising $CuSO_4$ from 0.1 to 1.0 mM in the pretreatment medium appeared to stimulate AO level (10-20 per cent.).

The lower level of AO in extracts from substrate pretreated embryos is probably due to an inactivation of the enzyme *in vivo*, probably similar to the one readily observed *in vitro*: pretreatment consisting of transfer of embryos after 3½ days on control medium, when AO has reached its top level, to 1-5 dp containing medium for 1½ days also resulted in a lowered AO level when compared with a pretreatment on a continuous control medium, even though 1-5 dp was added during preparation of both extracts.

It is noteworthy that pretreatment with 1-5 dp inhibited growth in length after 4 days of incubation. This could be due to the AO reaction providing in its product, H_2O_2, a ready hydrogen acceptor for the "IAA oxidase system" and finally causing a lowered level of IAA.

Amino acid activating enzymes in endosperms of the ripening grain of wheat

R. Cohen

Amino acid activation, which consists of the formation of amino acid-adenosine monophosphate complexes, is considered to be an important step in protein synthesis. Amino acid activating enzymes have now been shown to exist in young endosperms of wheat.

In the assay used to study these enzymes, activity is measured by the exchange of P^{32} labelled pyrophosphate with

adenosine triphosphate, in the presence and absence of particular amino acids.

Good purification of extracts has been obtained using Sephadex columns. This is evidenced by ratios of leucine values to blank values consistently higher than 10 to 1. It should be added that leucine has always catalyzed the exchange reaction to a greater extent than any other of the amino acids so far tried. Of these, proline, cysteine and valine have given values of the order of 30-70 per cent. of the leucine value, but those for lysine, tyrosine and histidine have been in the 10-30 per cent. range. So far, exchange has been only slightly or not at all stimulated by the addition of aspartic acid, tryptophan, glutamine or glutamic acid.

The cell division inducing activity from apple fruitlets

J.A. Zwar, N.P. Kefford (W. Bottomley, M.I. Bruce - Biochemistry Section)

Chemical properties

Large scale purification of the activity in apple extract:- Increased knowledge of the behaviour of the cell-division activity from apple extracts on ion-exchange columns has allowed the use of displacement from Dowex 50 resin by ammonia as the initial purification step. Large columns handling extract equivalent to 3 kg of fresh fruitlets have functioned satisfactorily. The elution of activity with pyridine from specially activated carbon columns has also been used successfully on a large scale. These purification steps are now used routinely.

Fractionation of the active material into components:- During the year evidence has accumulated showing that the apple extract contains more than one component, independently active in cell-division. First evidence came from the use of paper strip chromatography and was confirmed using this technique combined with elution from a rolled paper column (LKB "Chromax"). Good separations into 4 peaks of activity were obtained. Using methylethylketone, acetic acid, water (4:1:1) as solvent the R_F values of the active peaks were:- (i) 0.76, (ii) 0.37-0.47, (iii) 0.27-0.34, (iv) 0.13-0.23. The peak (iv) was not eluted from a paper column by this solvent but by butanol saturated with ammonia.

Gradient elution of the activity from Dowex 50 resin columns with HCl has also revealed four peaks of activity.

Cell-division activity and ultra-violet absorption:- Workers in other laboratories have reported that they can correlate cell-division activity in their extracts with ultra-violet absorption characteristics of purines. Extensive tests upon fractions from columns, and on paper strip chromatograms, have failed to reveal any correlation between activity and the compounds in apple extract which absorb ultra-violet radiation or give colour reactions for purines.

Biological properties

Activity of apple extract towards potato tuber:- Tobacco stem pith tissue, our normal assay tissue for cell-division activity has disadvantages associated with maintenance of supply. Thus the activity of apple extract towards potato tissue, which is in constant commercial supply, was tested. Blocks of potato tissue were induced to divide in the presence of auxin and casein hydrolysate; but division was too slow and irregular for the tissue to be used in a biological assay.

Preservation of chlorophyll in excised leaf discs:- Fractions from apple extract active in cell-division have been found to preserve the chlorophyll in excised leaf discs of *Nicotiana glutinosa* as does the synthetic cell-division inducer kinetin. This reaction is not of possible use as a biological assay for the activity in apple extract, as machine fractions also gave the reaction.

Irreversible inhibition of pea stem section elongation by Kinin:- Kinetin is known to inhibit the orientation of cell enlargement in tissue sections capable of both cell-division and enlargement. This is possibly a simple case of the regulation of the change from one phase of cell growth to another, and the process deserves greater definition. In addition, its interest as a possible natural process would be increased if a natural kinin produced similar effects.

It was found that the inhibition of pea stem section elongation was not reversible by the addition of the cell-enlargement regulators auxin or gibberellin. A brief treatment with kinetin also produced irreversible inhibition of elongation.

A highly purified extract of apple fruitlets, active in cell division, produced similar effects.

These results indicate that a short time after treatment with a cell-division regulator, the elongation of pea stem cells

is inhibited in a manner which cannot be reversed by auxin or gibberellin.

The growth of grass plants under natural conditions

C.N. Williams

The growth of seven grass varieties covering a range of vegetative and flowering types is being studied under field conditions. The plants are growing on two aspect sites having different temperature maxima, and the object of the study is to investigate growth patterns over a year and into the following spring.

Under the exceptionally moist conditions of the spring and early summer of 1961/62, large differences in growth on the two aspect sites were not observed. Plants on the cooler site were generally ahead in dry weight from mid-October to early December but not after this, indicating that only the early stages (possibly germination or establishment) were promoted on the cooler site.

In the late summer, under moisture stress, varieties which had not flowered continued leaf production and remained green for longer than those which had flowered.

The observations are being continued over a winter season and information on winter growth will be supplemented with auxanometer measurements of the growth of individual leaves on the two aspect sites.

PUBLICATIONS

Evans, L.T. (1961). - The use of controlled environments in plant improvement. Conf. Cereal and Pasture Breeders 1: 28.

Evans, L.T. (1962). - Inflorescence initiation in Lolium temulentum L. III. The effect of anaerobic conditions during photoperiodic induction. Aust. J. Biol. Sci. 15: 281-90.

Evans, L.T. (1962). - Daylength control of inflorescence initiation in the grass Rottboellia exaltata L.f. Aust. J. Biol. Sci. 15: 291-303.

Goldacre, P.L., Unt, H., and Kefford, N.P. (1962). - Cultivation of isolated tissue derived from the pericycle of roots. Nature, Lond. 193: 1305-6.

Grant Lipp, A.E., and Ballard, L.A.T. (1962). - The effect of carbon dioxide treatment of seeds on flowering in subterranean clover. Aust. J. Biol. Sci. 15: 406-8.

Kefford, N.P., and Bonner, J. (1961). - Steady state growth of Avena coleoptile sections in high auxin concentrations. Pl. Physiol. 36: 323-5.

Kefford, N.P., and Goldacre, P.L. (1961). - The changing concept of auxin. Amer. J. Bot. 48: 643-50.

Kefford, N.P. (1962). - The inactivity of 1-docosanol in some plant growth tests in relation to the auxin of Maryland Mammoth tobacco. Aust. J. Biol Sci. 15: 304-11.

Kefford, N.P. (1962). - Auxin-gibberellin interaction in rice coleoptile elongation. Pl. Physiol. (In press).

Morse, R.N., and Evans, L.T. (1962). - Design and development of Ceres - an Australian phytotron. J. Agric. Engng. Res. (In press).

Rijven, A.H.G.C. (1961). - Regulation of glutamyltransferase level in germinating wheat embryos. Biochim. Biophys. Acta 52: 213-5.

Rijven, A.H.G.C., and Cohen, R. (1961). - Distribution of growth and enzyme activity in the developing grain of wheat. Aust. J. Biol. Sci. 14: 552-66.

Rijven, A.H.G.C. (1961). - Distribution of glutamyltransferase in the ripening pea seed. Aust. J. Biol. Sci. 14: 700-1.

Williams, C.N. (1961). - Effect of inoculum size and nutrition on the host/parasite relations of Striga senegalensis on sorghum. Plant and Soil 15: 1-12.

Williams, C.N. (1961). - Growth and morphogenesis of Striga seedlings. Nature, Lond. 189: 378-81.

Williams, C.N. (1961). - Tropism and morphogenesis of Striga seedlings in the host rhizosphere. Ann. Bot. Lond. N.S. 25: 407-15.

Williams, C.N. (1962). - Investigations on the curvature of the Striga radicle. Ann. Bot. Lond. (In press).

AGRICULTURAL PHYSICS

Agricultural Physics is a term used to denote the application of physical and mathematical principles and techniques to problems related to the plant sciences and agriculture.

An important field of plant research is the study of the physics of plant environments. A clear understanding of the environment is necessary to evaluate its influence on the growth, production and life history of plants. The energy and water balance of vegetated surfaces include the most important aspects of the physical environment of plants and thus much of the work of this Section has been concentrated along microhydrological and micrometeorological lines. A related programme of investigation of the gaseous exchange between the plant and its surroundings is being initiated.

SOIL WATER STUDIES

Unsaturated flow properties of soils

D.E. Elrick

The unsaturated flow properties of soils may be characterized by the moisture content-soil moisture suction and capillary conductivity-soil moisture suction relations. Experiments to determine the flow properties are based either on the steady-state Darcy equation or on the transient diffusion equation. An apparatus has been designed to compare the steady-state and transient methods on the same sample. Although only preliminary results are available, these indicate that the transient outflow pattern at high moisture contents using a coarse sand differs considerably from that predicted by the theory. The extended theory which takes into account the air as well as the water phase also does not agree with the observed transient behaviour at high moisture contents. At low moisture contents the agreement between the two methods is considerably better.

It is proposed that one must distinguish between steady-state and transient flow conditions when attempting to describe the flow behaviour of porous materials. An excessively slow approach to equilibrium was observed at the higher moisture contents which makes the transient outflow method for determining the flow parameters inapplicable in this range. Much of the difficulty is attributed to changing contact angles and to the lack of continuity of the air phase at the higher moisture contents.

Air entrapment during the infiltration of water into soil

A.J. Peck

In studies of the infiltration of water into soil the role of the gaseous phase, air, is generally neglected. There is evidence that in certain circumstances an excess of air pressure within the soil over the atmospheric pressure develops during infiltration. In the literature there is some speculation about the effect of this excess pressure on the process of infiltration.

A fairly comprehensive study of air entrapment in soils has been initiated. This includes work on water transfer in aggregated soils where air may be entrapped within aggregates.

Experiments are in progress to determine the effects of air entrapment on the infiltration or absorption of water into various soils of effective profile depths between about ½ and 3 metres. An attempt is to be made to obtain numerical solutions to some of the relevant mathematical equations using a newly developed technique which allows the inclusion of hysteresis effects. It seems that this technique will be very tedious if reasonably accurate results are required.

MICROMETEOROLOGY

The microclimate of light and carbon dioxide in relation to plant growth in the field

O.T. Denmead

The aims of the project are to make direct measurements of plant growth in the field by determining the rate at which carbon dioxide gas is transferred between the atmosphere and growing crops and to relate the transfer of carbon dioxide to various factors of the crop microclimate. These factors include the CO_2 concentration itself, the amount and quality of incident light energy and its distribution within the canopy, the magnitude of turbulence in the atmosphere both above the crop and within it, and the supply of soil moisture. The information obtained will provide a rational basis for examining the physical environment in which plants grow in the field. Essentially, it is a study of the physics of the plant canopy and represents a

basic approach to an understanding of the principles of crop production and pasture measurement.

Like the flux of water vapour in evaporation and the fluxes of heat and momentum, the flux of carbon dioxide is a turbulent transfer process. As such, it can be measured in the field by the techniques of micrometeorology. Necessary measurements include the vertical gradient of carbon dioxide concentration above the crop and the turbulent transfer coefficient (the diffusivity of carbon dioxide in a turbulent air stream). The vertical gradient of carbon dioxide concentration will be measured continuously and automatically with an infra-red gas analyser, while the turbulent transfer coefficient will be estimated by at least three independent methods. Wind profile data will be used for one estimate. A second estimate will be obtained from energy balance measurements. A third estimate will be sought from the records of an automatic weighing lysimeter in conjunction with measurement of the vertical profile of absolute humidity. The lysimeter will also provide a continuous measurement of evapotranspiration. Necessary supplementary measurements which will be made include net radiation, soil heat flux and vertical temperature profiles.

It is planned to make the initial measurements in a wheat crop in a field near Canberra. The site has been surveyed and preliminary wind profile measurements indicate that a good meteorological exposure with a "fetch" of from 300 to 500 metres can be obtained. Equipment is on order or is being developed for the project and it is hoped to make some measurements during the 1962 growing season.

Measurement of the radon content of air as a tracer of atmospheric turbulence

O.T. Denmead and D.E. Elrick

Perhaps the most difficult problem in micrometeorology is to estimate the turbulent transfer coefficient (a measure of the turbulent mixing that occurs in the atmosphere). Three independent methods for estimating this parameter were mentioned in the CO_2 project. The present project is planned to give a fourth estimate from measurements of the atmospheric content of radon. This is a naturally-occurring radioactive gas which is evolved at a small but fairly constant rate from the decay of radium minerals in the ground and is diffused in the atmosphere by turbulent mixing. Techniques based on the radioactivity of radon are being developed in order to measure the emanation of radon from the

ground and its subsequent vertical distribution in the atmosphere. From this information, the turbulent transfer coefficient will be calculated.

The use of radon as a tracer of air turbulence has been advocated by several people but, as yet, the technique is relatively untried. Its successful application would represent an important contribution not only to those programmes of the section which involve turbulent transfer processes, but also to micrometeorology in general.

Experimental study of advection

N.E. Rider and E.F. Bradley

The analysis of the experimental work performed at the Canberra airport site has been completed, and the results compared with the theory developed by J.R. Philip. The shape of the temperature and humidity profiles as modified by the discontinuity in surface moisture conditions conforms closely to the predictions of advection theory, although the absolute values of temperature and humidity changes downwind show slight but systematic discrepancies. A possible explanation may be the inequality of the values of eddy diffusivity for heat and water vapour, assumed identical in the theoretical treatment.

Direct calculation from the observed profiles reveals that the mean evaporation rate between the leading edge and 1 metre, 4 metres and 16 metres downwind was respectively 3.7, 2.5, and 1.7 times that expected as a result of solar radiation alone. These figures suggest that the evaporation rate varies as an 0.72 power of x (the distance downwind), a more rapid fall of evaporation rate with distance than that predicted by Sutton who gives the power as 0.89.

Study of the effect of a change in surface roughness on the turbulent transfer of momentum

E.F. Bradley

Spatial changes in surface conditions, for example the change in roughness existing in the advection experiment, occur frequently, though current micrometeorological theory deals almost exclusively with aerodynamically homogeneous surfaces. At the present time no adequate theoretical or experimental studies of this problem exist, but it is believed that the matter can

profitably be studied by modifying and extending existing theories, and by developing and using appropriate instrumentation.

The initial investigation will be the effect of artificially produced roughness change on the shearing stress at the surface. Development of drag plates for these measurements has proved extremely difficult, but a prototype has been built which promises to satisfy the conflicting requirements of simplicity and cheapness with sensitivity.

FLUID MECHANICS

Stokes flows

J.R. Philip

Flow through regions with circular boundaries:- Flows in porous media possess a convergent-divergent character which is totally absent from flows through the conventional "capillary bundle" model of porous media. The present study of Stokes flows between sources and sinks in the solid boundary of a circular region is aimed at elucidating the effects of successive convergence and divergence. Exact solutions have been obtained which indicate reversals of pressure gradient close to the wall in broad parts of the flow channel. These are associated with points of inflexion in the velocity profiles and with regions where maximum shearing stress occurs away from the wall. The results therefore indicate a mechanism of clogging of porous media when infiltrated with thixotropic colloidal suspensions. Further work to extend the results to cases where the sources and sinks are of finite dimensions is proposed.

Flow behind interfaces:- The interesting problem of the flow pattern in the neighbourhood of air-water interfaces in media such as unsaturated soil was discussed in last year's report. The basic mathematical problem has now been solved, the singularity which vitiated earlier numerical work has been recognized and "subtracted out" of the problem. Numerical techniques for completing the solution have been developed.

The interrelation between convection and molecular diffusion

J.R. Philip

The dispersal of a substance (e.g. a solute in a liquid, or a component in a mixture of gases) in a flowing fluid arises

in two ways - through convection and through molecular diffusion. The basic mechanisms at work are the same whether the problem be one of dispersal during flow through a porous medium, dispersal due to mechanical or biological stirring, or that of dispersal in a turbulent flow field.

By use of suitable "Lagrangian" co-ordinates the direct kinematic effect of convection may be separated from the problem (and can be regarded, in a sense, as reversible). The effect of the history of convective strain on the molecular diffusion field is, however, irreversible. The present study has shown how the effect of convection on diffusion in the Lagrangian co-ordinate system is to distort the diffusivity tensor.

By use of matrix calculus, very general methods of solution of the problem have been developed. They are being applied to a range of particular cases of time-dependent convection of theoretical and practical interest.

The relation between Eulerian and Lagrangian statistics in turbulent diffusion

J.R. Philip

A fundamental difficulty in the statistical approach to turbulent diffusion is that the Eulerian statistics of the turbulent velocity field are the simplest and most natural to measure, whereas the statistics of dispersal are directly connected with the Lagrangian statistics; yet virtually nothing is known about the connection between the Eulerian and the Lagrangian statistics.

In the present work on homogeneous turbulence, it has been shown that under the (not very restrictive) assumption that the probability distribution functions governing the dispersal of an individual particle are normal, the Eulerian and Lagrangian correlation functions are connected by an integral equation.

When certain plausible and mathematically convenient forms are taken for the Eulerian correlation function, the Lagrangian function can be computed readily. The results give relations between Eulerian and Lagrangian time scales which are consistent with the available experimental data.

Diffusion in uniform shear flow

D.E. Elrick

The transport of matter or heat under simultaneous conditions of diffusion (either laminar or turbulent) and convection has been studied. The convective velocity has been restricted to the simple case of uniform shear flow. This mathematical approach is a first step in a study of the movement of nutrients (in the soil solution) to the plant root surface. The mathematics can also be extended to describe the dynamic diffusion of heat or matter in a turbulent atmosphere having a uniform shear field. Solutions for instantaneous point and line sources have been obtained using Fourier transform methods.

Simultaneous diffusion and convection

D.E. Elrick

The study initiated in the previous project is being continued by analyzing the combined diffusion and convection problem under different convective flow patterns. Work is also continuing in an attempt to use the present solutions to fit prescribed boundary conditions of general interest.

PUBLICATIONS

Denmead, O.T. (1962). - Availability of soil water to plants. Third Aust. Conf. Soil Sci. Paper No.46.

Denmead, O.T., Fritschen, L.J., and Shaw, R.H. (1962). - Spatial distribution of net radiation in a corn field. Agron. Jour. (In press).

Denmead, O.T., and Shaw, R.H. (1962). - The availability of soil water to plants as influenced by soil moisture content and meteorological conditions. Agron. Jour. (In press).

Elrick, D.E. (1962). - Source functions for diffusion in uniform shear flow. Aust. J. Phys. 15: (In press).

Elrick, D.E. (1962). - Unsaturated flow properties of soils. Third Aust. Conf. Soil Sci. Paper No.36.

Rider, N.E., Cruickshank, I.A.M., and Bradley, E.F. (1961). - Environment and sporulation in phytopathogenic fungi. III. Peronospora tabacina Adam: field environment, sporulation, and forecasting. Aust. J. Agric. Res. 12: 1119-25.

Rider, N.E., and Bradley, E.F. (1962). - The digitization and integration of reflecting galvanometer deflections. Rev. Sci. Instrum. 33: 25-26.

PLANT ECOLOGY

The research programme of this Section is directed primarily towards studies of interactions between plant communities or individual species and their environment. Because of the diversity of communities and environments, the activities of the Section cover a wide field.

Reduced catchment values in the Snowy Mountains have followed depletion of the vegetation by fire and grazing. Regeneration of the plant communities, and methods of revegetating the badly eroded summit areas are being studied. In spite of the limited resources available, progress has been made in the study of Quaternary history in the high mountains and surrounding tablelands.

More detailed information about the rain forests of Eastern Australia is being obtained, attention being concentrated on the tropical rain forests of North Queensland. Correlations are being sought between botanical composition and structure of the different forest types and the environment. Further glasshouse studies are being made in relation to regeneration and distribution of silky oak (Grevillea robusta).

In studies of the environment in relation to the distribution of natural communities in the Southern Tablelands and Monaro Regions, attention is at present being concentrated on soil factors. Autecological studies of the naturalized Medicago spp. are being continued in the semi-arid regions.

In pasture ecology, emphasis is placed on methods of increasing production during critical periods and on the effects of defoliation on the persistence of perennial grasses. These investigations have included seasonal production of a number of perennial grasses, and the effect of aspect on the growth of pasture species, especially during the winter period. Field studies of the effects of defoliation of perennial grasses have been initiated.

Insect pests of pastures cause economic losses in the New England Region. An investigation of this problem has been commenced in co-operation with the Division of Entomology.

Autecological studies of some of the more important pasture weeds are an important activity in the Section, with

emphasis on environmental conditions favouring weed invasion, and the role of pasture species in their control. Preliminary studies of some of these weeds have been completed, and attention is now being directed to a more detailed study of their distribution and environmental relationships, including the effects of competing species.

ALPINE ECOLOGY

Condition and trend of plant communities and soils

A.B. Costin, D.J. Wimbush and R.N. Cromer

These long-term studies are designed to measure changes in vegetation and soil conditions. Special attention has been given to the problem of simplifying procedures with a view to reducing variations in measurement by different workers. Point quadrats have been found preferable to line intercepts, and extensive use is being made of stereoscopic photographs of permanent quadrats.

Catchment improvement

A.B. Costin, D.J. Wimbush and R.N. Cromer

The most serious problem in the revegetation of the high mountain catchments is that of the badly eroded summit areas, for which suitable primary colonizing species have not yet been found. Ladino clover appears to be superior to various races and strains of Trifolium ambiguum. Of the native species, Craspedia uniflora shows promise. The use of native meadow hay as a mulch has been followed by promising regeneration of native species.

Quaternary ecology

A.B. Costin

Progress has been made in elucidating specific problems and in formulating a general hypothesis of Quaternary ecological history for the Monaro Region. Preliminary data have been obtained by investigations of landscape features, soils, and sedimentary deposits. Relic periglacial features are widespread, and there is evidence that several periglacial phases have occurred during the last 15,000 years.

On the basis of C^{14} dates so far available, it is tentatively concluded that the last main Kosciusko glaciation commenced to wane about 16,000 years ago, and had completely disappeared by about 10,000 years before present. About 4,000-5,000 years ago there was a fall in mean annual temperature of up to $5^{o}C$ with a return to periglacial conditions above 6,000 feet. The present regime, with slightly higher temperatures, dates from about 2,000-3,000 years ago. The general conclusion concerning most of the plant communities is that they are relatively young, in contrast to the plant species themselves, which are old.

RAIN FOREST ECOLOGY

Ecological relations in Rain Forest in Eastern Australia

L.J. Webb and J.G. Tracey

Following earlier general surveys, an attempt is being made to describe representative rain forest types by profile sketches and identification of all species on 0.1-0.5 acre plots. Current work is being concentrated on making more intensive studies of this kind in the tropical rain forests of North Queensland. Forest types are being correlated with gradients of latitude, altitude, soil moisture, drainage, nutrient availability, and historical factors such as fire. From the data obtained, it may be possible to construct "formation-series" and show edaphic differentiation of forests within the tropical, subtropical and lower montane (warm temperate) zones.

The present distribution of tropically derived rain forests in eastern Australia suggests the possibility of edaphic compensation under limiting climatic conditions. Such forests extend southwards to about Nowra (lat. $36^{o}S$) on basaltic krasnozems and similarly well-drained soils derived from basic igneous rocks and calcareous sediments. The survival of these tropical types after a period of presumably Recent cooling apparently depended on physiological adaptations related to high soil nutrient status.

Comparisons of rain forests in Australia and Eastern Brazil indicate different roles of climate, soils and phytogeographical history of the floras. There is an interesting equivalence between the Brazilian _campos cerrados_ and Australian sclerophyll vegetation. Both are evergreen, and in both the scleromorphism may be related to oligotrophic as well as to xeric conditions.

Studies of plant interference and regeneration patterns

L.J. Webb and J.G. Tracey

Evidence from field and glasshouse experiments suggests that a water-soluble substance, toxic to seedlings of the same species, may be produced by actively growing roots of Grevillea robusta. Further glasshouse trials are in progress.

Observations are being made on the distribution and survival of seedlings of non-gregarious rain forests species in relation to presence of adult trees of the same species.

Nutrient circulation

L.J. Webb and J.G. Tracey

Studies of leaf-fall in subtropical rain forest on basalt, warm temperate rain forest, and wet sclerophyll forest on rhyolite have been made at Whian Whian in New South Wales. The litter from each type of forest has been analyzed for N, P, K and Ca.

The greatest annual return of nutrients through leaf-fall occurs in the subtropical rain forest, and the least in warm temperate rain forests.

VEGETATION AND ENVIRONMENT

Natural communities and soil calcium

C.W.E. Moore and W.A. Bruce

An examination of the soils from a Dry Sclerophyll Forest with Eucalyptus rossii dominant and a small neighbouring area of uncleared Savannah Woodland with E. melliodora dominant has confirmed earlier reports that the soils of the former community are deficient in calcium, whereas those of the latter are well-supplied.

An attempt is being made to determine the extent to which soil calcium is likely to be a significant factor in the distribution of other natural communities. Data are yet incomplete, but it is clear that the soils of Dry Sclerophyll Forests have a low calcium status. The highest values obtained so far have been

from rain forest soil.

Ecology of Serpentine soils

C.W.E. Moore and W.A. Bruce

Preliminary work which established that the serpentine soil is deficient in exchangeable calcium was followed by an attempt to determine the significance of this soil characteristic in relation to the distribution of Eucalyptus pauciflora (on serpentine) and E. delegatensis (on basalt). Failure to obtain convincing evidence is attributed in part to the high proportion of genetic dwarfs amongst the E. pauciflora seedlings, and to apparent deficiencies of iron and manganese in the serpentine soil, both of which were accentuated by addition of calcium.

PASTURE ECOLOGY

Seasonal production of sown perennial grasses

E.F. Biddiscombe and B. Quinlan

A study has been made of the performance of a number of perennial grasses with a view to comparing summer and winter production with that of Phalaris tuberosa. The grasses were sown in pure stands, and subjected to heavy stocking (up to 9.6 sheep per acre) during the appropriate season. This experiment has now been completed, and none of the species tested has proved to be as persistent as Phalaris.

Phalaris:- For summer grazing, Bromus inermis was superior to Phalaris for two seasons. Sheep grazing this species had slightly higher liveweights, and wool production was 18 per cent. above that of sheep on Phalaris pasture. Subsequently the plants were seriously weakened, and the plots were invaded by annual grasses.

Brignoles cocksfoot (Dactylis glomerata) was at first exceptionally vigorous and gave 15-20 per cent. greater liveweight and wool yield than Phalaris during the four winter months of the first two grazing years. In the third year the performance of this species was below that of Phalaris. A dense stand of seedlings developed during this period, and in the following year animal production on these plots increased.

One interesting feature arising from this work is that the annual dominant pastures which developed on depleted plots were more productive than Phalaris. In the Tablelands environment it may therefore be advantageous to supplement Phalaris pasture with suitable annual grasses or crops for grazing during critical periods.

Microclimate and pasture production

E.F. Biddiscombe and B. Quinlan

A series of small-plot experiments has been established on slopes of different aspect to study species-aspect interactions at different seasons. In particular, the effects of soil and air temperatures on the growth of pasture species have been studied. During the past 12 months, attention has been concentrated on winter growth of subterranean clover, Phalaris tuberosa, and Brignoles cocksfoot (Dactylis glomerata).

When the clover is established early and makes autumn growth, yield on the northerly aspect is significantly higher than on the southerly aspect during July, August, and September. Growth differences appear to be related to temperature of the surface soil. Both grasses were similarly favoured by the northerly aspect, but the cocksfoot showed by far the greater response.

Effect of defoliation on perennial grasses

R.M. Moore and J.D. Williams

Glasshouse studies on the effects of defoliation of a perennial grass showed that cutting had a pronounced effect on regrowth under conditions of low light, high nitrogen, and high temperature. The most significant factor was light, and its greatest effect was on root growth.

This study has now been extended to the field, where the effects of nitrogen, phosphorus and defoliation on native perennial grasses are being examined.

Sheep mortality on Phalaris tuberosa pasture

R.M. Moore and R.J. Hutchings

Sudden deaths among Merino sheep grazing Phalaris tuberosa pastures may at times cause serious stock losses. An attempt is being made to define the conditions under which sudden

death occurs, and to determine the cause of death.

Preliminary results appeared to implicate high nitrogen levels in Phalaris, but attempts to induce the condition experimentally on pastures heavily fertilized with nitrogen have so far proved unsuccessful.

Levels of calcium, potassium and magnesium in the blood of animals given extracts of Phalaris are being determined. The limited data so far available indicate that there may be an increase in blood magnesium following forced ingestion of Phalaris.

Autecology of Themeda australis

C.W.E. Moore

Studies of the root system of Themeda australis at two sites have shown that Themeda is a deep-rooting species, and that the roots penetrate heavy clay soils. At Site 1, the root system was studied to a depth of 69 inches, but it was clear that a few roots penetrated to a depth in excess of 6 feet. At Site 2, the soil depth was 4 feet, but roots of Themeda were observed to penetrate cracks in the bed-rock, where it was not possible to determine maximum depth.

The bulk of the roots is found in the surface soil. At Site 1, 59 per cent. (dry weight) of the roots occurred in the 0-6" layer, and 71 per cent. in the 0-12" layer. At Site 2, the figures were 53 per cent. and 69 per cent. respectively. Similar studies are to be made at other sites.

Insect pests in pastures

R.L. Davidson

The larvae of a number of insects (e.g. Sericesthis and Othnonis) damage pasture grasses by ingesting the root systems. In most areas of the Northern Tablelands of New South Wales, localized outbreaks have occurred from time to time when one or other of the species involved has reached enzootic proportions. Though these insects damage the native grasses, the problem becomes particularly acute in sown pastures, when a large proportion of the grasses may be killed.

An investigation of this problem has recently been commenced in co-operation with the Division of Entomology. It is proposed to make a detailed study of the physical and chemical

factors of the environment, especially the soil environment, to determine the extent to which environmental changes can be induced by pasture management, and the extent to which such changes are inimical to the development of heavy infestations.

Medicago species

W.D. Andrew and R.W. Kirchner

In the Macquarie Region of New South Wales, a survey of the Medicago spp. showed that their distribution was closely related to major soil groups. Attempts are therefore being made to determine which soil factors are of significance in relation to medic distribution. A glasshouse trial designed to obtain data on the effects of soil and nutrient status on the two most common species (M. denticulata and M. minima) showed no species/soil interaction. Further work is planned to elucidate the problem.

In semi-arid regions, and in special sites in higher rainfall areas, saline soils may be important. Establishment of pasture on these soils requires the selection of salt tolerant species. Medicago spp. differ in their tolerance of salinity, and recent work, in co-operation with Mr. H. Greenway, at the Irrigation Research Station, Griffith, has shown that when seedlings are grown in saline nutrient solutions, health ratings can be devised which correlate well with field performance.

WEEDS ECOLOGY

Distribution of alien plants in Australia

R.M. Moore and W.F. Straatmans

A broad scale survey of the distribution of alien plants in temperate Australia has been completed, and a few species selected for more detailed study.

An attempt to relate the climatic distribution of a number of species in Australia to their climatic ranges in their countries of origin was largely unsuccessful, because soil and land use factors often override climatic factors.

Soil nitrogen and weed invasion

R.M. Moore and J.D. Williams

The levels of available soil nitrogen are being studied in native and sown pastures, and at different stages of secondary succession, to determine possible relationships between nitrogen level and the occurrence of alien species.

Weed invasion of Phalaris pastures

R.M. Moore and J.D. Williams

Phalaris tuberosa-subterranean clover pastures are normally stable in composition, and not subject to serious weed invasion, but there is increasing evidence that old pastures may become weedy.

An old established pasture has been grazed for 12 months at 8 sheep per acre. Different plots were grazed by an additional 6 sheep per acre for different 6-weekly intervals throughout the year. The grazing treatment has now been discontinued, and the growth and botanical composition of the pastures are being examined.

Scotch thistle (Onopordum spp.)

P.W. Michael and J.A. Robertson

Comparative trials between Phalaris tuberosa and Brignoles cocksfoot (Dactylis glomerata) in a number of areas have demonstrated the superiority of the cocksfoot as a competitor for Onopordum, in terms of both grass production and thistle control. Subterranean clover has not grown well in association with cocksfoot, and the possibilities of lucerne-cocksfoot mixtures are being investigated.

Soursob (Oxalis pes-caprae)

P.W. Michael and J.A. Robertson

Investigations into the control of soursob in co-operation with the South Australian Department of Agriculture, have now been completed. It has been shown that the level to which bulb infestation can be reduced by herbicides depends on the intensity of infestation, and that in heavily infested areas reduction of bulb weights by cultivation is a necessary

prerequisite to spraying. For heavily infested areas, therefore, a two-year control programme has been developed as follows:-

1st year: Cultivation at the time of old bulb exhaustion, and again 6 weeks later, followed by sowing a cereal crop.

2nd year: Spraying with a mixed esters formulation of 2,4,5-TP at 2 lb per acre at the time of old bulb exhaustion, followed by preparation for a second cereal crop not less than 4 weeks after spraying.

By this method, bulb weights can be reduced to less than 1 cwt per acre, thus ensuring long-term control.

Serrated tussock (Nassella trichotoma)

J.A. Carnahan

Preliminary trials using various chemical treatments with and without subterranean clover have been completed. Application of 2,2-DPA in autumn at 4 lb per acre active ingredient to regrowth following fire or desiccation with diquat dibromide was the most effective treatment. The effects of subterranean clover sown after this treatment at 6 lb per acre with 6 cwt per acre of superphosphate were superior to those obtained by sowing the clover into untreated plots. Stimulation of volunteer clovers (Trifolium arvense, T. campestre, and T. glomeratum) by application of 6 cwt per acre of superphosphate had similar effects to those of the subterranean clover.

An attempt to establish perennial pasture species by surface sowing in plots in which subterranean clover had been established for three years proved unsuccessful.

Austral bracken (Pteridium esculentum)

J.A. Carnahan

Preliminary trials designed to determine the effects of herbicides and the establishment of pasture species on bracken have been completed.

4-CPA at 5 lb per acre acid equivalent reduced frond numbers to about 60 per cent. in the growing season following treatment, and twelve months later no recovery could be detected.

A pasture mixture was successfully established by surface sowing in the autumn, the most successful species being Akaroa cocksfoot (Dactylis glomerata). Neither the application of a chemical desiccant prior to sowing nor previous treatment with 4-CPA appeared to affect the percentage ground cover of the sown species. When sowing of pasture species was accompanied by application of 6 cwt per acre of superphosphate, frond numbers and bracken cover were reduced to about 60 per cent. of those in control plots.

PUBLICATIONS

Andrew, W.D. (1962). - Behaviour of annual species of Medicago introduced into a Medicago minima (L.) Bart. - dominant disclimax community. Aust. J. Agric. Res. 13: 212-9.

Andrew, W.D., Neal-Smith, C.A., and Hutchings, R.J. (1962). - Behaviour of leguminous species on moderately saline soil at the Ginninderra Field Station, A.C.T. Field Station Record 1: 41-44.

Biddiscombe, E.F., Arnold, G.W., and Scurfield, G. (1962). - Effects of gibberellic acid on pasture and animal production in winter. Aust. J. Agric. Res. 13: 400-13.

Cannon, J.R., Corbett, N.H., Haydock, K.P., Tracey, J.G., and Webb, L.J. (1961). - Antibiotic effects in plant communities. Nature, Lond. 190: 189-90.

Cannon, J.R., Corbett, N.H., Haydock, K.P., Tracey, J.G., and Webb, L.J. (1962). - An investigation of the effect of the dehydroangustione present in the leaf litter of Backhousia angustifolia F. Muell. on the germination of Araucaria cunninghamii Ait. - An experimental approach to a problem in rain forest ecology. Aust. J. Biol. Sci. (In press).

Carnahan, J.A. (1961). - Ecological interaction between introduced and indigenous plant species in the Manawatu district. Proc. N.Z. Ecol. Soc. 8: 15-22.

Costin, A.B. (1961). - "Forestry Hydrology of Australian Subalpine Catchments". Proc. Second World Eucalyptus Conference, Brazil.

Costin, A.B. (1961). - "Periglacial Features of the Monaro Region and their significance for Soil Formation". Symposium on Geochronology and Land Surfaces in relation to Soils in Australia. Aust. Acad. of Sci.

Costin, A.B. (1961). - "Scientific aspects of the proposed Kosciusko Primitive Area". Aust. J. Sci. 23: 397.

Costin, A.B., Gay, L.W., Wimbush, D.J., and Kerr, D. (1961). - Studies in catchment hydrology in the Australian Alps. III. Preliminary snow investigations. C.S.I.R.O. Aust. Div. Pl. Ind. Tech. Pap. No.15.

Costin, A.B., and Wimbush, D.J. (1961). - Studies in catchment hydrology in the Australian Alps. IV. Interception by trees of rain, cloud, and fog. C.S.I.R.O. Aust. Div. Pl. Ind. Tech. Pap. No.16.

Costin, A.B. (1962). - "National Parks in Australia". National Parks - A World Need. American Committee for International Wild Life Protection. Special Publ. No.14, pp.22-28. (New York).

Costin, A.B. (1962). - The soils of the High Plains. Roy. Soc. Vic. Victorian High Plains Symposium, 1961. (In press).

Costin, A.B. (1962). - The vegetation of the High Plains. Proc. Roy. Soc. Vic. (In press).

Davidson, R.L., and Purchase, H.S. (1961). - A preliminary comparison between two methods of urea supplementation of winter feed for beef cows. J. S. Afr. vet. med. Ass. 32: 85-9.

Davidson, R.L., Brynard, A.M., Gillard, P., Lecatsas, G., and Leigh, J. (1961). - Calibration of the belt transect method in Combretum woodland in the Kruger National Park. Koedoe 4: 31-44.

Davidson, R.L. (1962). - The influence of edaphic factors on the species composition of early stages of the subsere. J. Ecol. 50: (In press).

Holland, A.A., and Moore, C.W.E. (1962). - The vegetation and soils of the Bollon district in southwestern Queensland. C.S.I.R.O. Aust. Div. Pl. Ind. Tech. Pap. No.17.

Moore, C.W.E. (1961). - Competition between Eucalyptus melliodora and E. rossii at varying levels of exchangeable calcium. Aust. J. Bot. 9: 92-7.

Moore, R.M., Arnold, G.W., Hutchings, R.J., and Chapman, H.W. (1961). - Poisoning of Merino sheep on Phalaris tuberosa L. pastures. Aust. J. Sci. 24: 88.

Moore, R.M., and Robertson, J.A. (1962). - Studies on skeleton weed in the New South Wales wheat belt. Aust. J. Exp. Agric. Anim. Husb. (In press).

Moore, R.M., Arnold, G.W., and Hutchings, R.J. (1962). - Mortalities among sheep with Phalaris tuberosa pastures. Aust. J. Exp. Agric. Anim. Husb. (In press).

Robertson, J.A. (1961). - Chemical control of leafy Bossea. J. Aust. Inst. Agric. Sci. 27: 245-8.

Roe, R. (1962). - Mitchell grass plant counts - Gilruth Plains. Field Station Record 1: 19-20.

Roe, R. (1962). - Mitchell grass pasture - Gilruth Plains. Report of sampling February 1961. Field Station Record 1: 21-28.

Roe, R., and Mottershead, B.E. (1962). - Palatability of Phalaris arundinacea. Nature, Lond. 193: 255-6.

Webb, L.J., Tracey, J.G., and Haydock, K.P. (1961). - The toxicity of Eremophila mitchellii leaves in relation to the establishment of adjacent herbs. Aust. J. Sci. 24: 244-5.

Wheeler, J.L. (1962). - Within-paddock variation in the fertility of a virgin soil. Field Station Record 1: 13-19.

The research work of this Section is planned to investigate the utilization, the biology, and the improvement of grassland, with special reference to sown pastures in southern Australia.

Results from exploratory experiments have all pointed to the possibility that levels of utilization of pastures, far higher than those generally achieved in practice, might be achieved by stocking rates at about six sheep per acre. The economic consequences of such high utilization to the cost and level of animal production are so great that a large new project has been commenced to examine the commercial possibilities of high stocking rates. These experiments are intended to be a comprehensive examination of the effects of stocking rates of sheep and of cattle on the pastures, the animals, and the soil.

Further work is now being planned to examine the role of the senses, the physiological state of animal and pasture, and the environment on animal welfare and production, and on pasture growth. This knowledge will be used to plan management systems to improve the efficiency of animal production.

PROJECTS

Grazing experiments

K.W. Clark, D. Bennett and F.H.W. Morley

Three inter-related experiments have been commenced at Ginninderra Experiment Station. The basic plan is the comparison of kinds of stock and stock management over five levels of grazing intensity or equivalents, viz. 3, 4, 5, 6 and 7 Merino ewes per acre.

The treatments are: Breeding Merino ewes: Aberdeen Angus steers; or ewes and steers. A split management treatment compares continuous grazing versus autumn deferment at the high intensities, i.e. 5, 6, or 7 ewes per acre. There are 784 ewes and 92 steers on this experiment.

The first season has been especially favourable, so that differences in productivity per acre have been almost wholly a

function of stocking rate, production per head varying little.

Pastures have shown some interesting changes, those under heavier stocking tending to be more clover dominant. Availability has shown little variation under different stocking levels with sheep, but has been sharply reduced by heavy stocking with cattle.

The year has enabled techniques of handling animals and pastures to be developed and streamlined, and has helped to define some of the possibilities and limitations of this type of experiment.

Fat-lamb production

G.W. Arnold and H.W. Chapman

This experiment, which was stocked in March 1962 is designed to compare at three stocking levels (4, 5 and 6 ewes per acre), three pasture management systems, viz. continuous grazing, autumn deferment or autumn deferment plus creep feeding of lambs. Two stock management systems, i.e. mid-August lambing versus mid-September lambing are incorporated. The use of special purpose pastures is a further treatment being investigated. These pastures include Dactylis glomerata (Brignoles) and Bromus inermis grazed in conjunction with Phalaris tuberosa.

Three replicates are used, randomised to enable all contrasts to be tested for significance. Border Leicester x Merino ewes are mated to Dorset Horn Rams. Initially stocking rates will be 3, 4 and 5 ewes per acre.

The smaller fat lamb production experiment at Dickson has now stopped. The final crop of lamb carcasses is being studied by Mr. V. Khandaka, a Columbo plan trainee.

Comparison of species under grazing

F.H.W. Morley and A. Axelsen

A trial with seven different lines of perennial grasses has been set up both as a test of the species concerned, and as a study in methodology. Other aims include investigation of the role of lucerne in pasture production, and the wear of teeth. The lines are Lolium perenne (Tas. No.1), L. perenne (local ecotype), Dactylis glomerata (Currie and Brignoles) Festuca arundinacea (Demeter), Phalaris tuberosa (Australian), and

P. tuberosa x P. arundinacea (McWilliam). Also included will be Blando soft brome.

The perennial grasses were established in the spring of 1961, making splendid growth during the early summer. Grazing is to commence on an experimental basis, late 1962.

The food intake of grazing sheep

G.W. Arnold, W. McManus and J. Ball (Dept. of Wool Technology, University of New South Wales), and F.H.W. Morley

An experiment has been commenced to examine the effect of pregnancy lactation, and of pasture availability, on intake. A special experimental unit, consisting of a number of small plots (1/3 acre), has been constructed. Ewes with and without oesophageal fistulae are being trained for this work, and some special techniques are being tested.

The importance of pasture oestrogens on sheep reproduction

F.H.W. Morley, D. Bennett and A. Axelsen

No information exists on the effect of oestrogens continuously ingested immediately prior to and during mating. This would occur fairly frequently where ewes were mated, for a spring lambing, on sub. clover pastures which received substantial rain in late summer and early autumn. An experiment, with 280 Merino ewes, was set up using 3 levels of stilboestrol (8, 32 and 128μg/day), two periods before mating (15-32 and 30-50 days) and two periods following mating (0 and 15 days). Ewes were examined for milk production. A linear response of milk score to log. accumulated dose of oestrogen was found. Following this result ewes from paddocks with varying amounts of sub. clover were examined, and a clear relationship between mammary activity and clover content of pastures was found. This indicates that ewes were ingesting substantial quantities of oestrogen from these pastures. The reproductive performance of these ewes will be followed.

A technique of pasture estimation

F.H.W. Morley, K.W. Clark and D. Bennett

A technique for estimation of the amounts of green grass and clover, and of dry material, without extensive pasture

laboratory or cutting work, has been developed. Several observers score the pastures, and their scores are transformed by the use of a calibration curve determined from scores given to cut quadrats. The technique is being applied each month on the large grazing experiment where it combines generally acceptable accuracy with practicability.

Experimental surgery

H.W. Chapman and F.J. Hamilton (Division of Animal Health)

Improved techniques for oesophageal fistulation have been developed and used both in crossbred and Merino sheep, and in calves.

The effect of volatile fatty acids on wool production

M. Freer

The effect of intra-ruminal infusion of different volatile fatty acids, in isocaloric amounts, on the wool production of wethers fed a basal diet of hay, will be investigated. Concurrent digestibility tests are planned.

PUBLICATIONS

Arnold, G.W. (1962). - Effects of pasture maturity on the diet of sheep. Aust. J. Agric. Res. (In press).

Arnold, G.W. (1962). - The influence of several factors in determining the grazing behaviour of Border Leicester x Merino sheep. J. Brit. Grassl. Soc. 17: 41-51.

Arnold, G.W., and Bush, I. (1962). - The effects of stocking rate and grazing management on fat lamb production. Proc. Aust. Soc. Anim. Prod. (In press).

Arnold, G.W. (1962). - Factors within plant associations affecting the behaviour and performance of grazing animals. J. Ecol. (In press).

Biddiscombe, E.F., Arnold, G.W., and Scurfield, G. (1962). - Effects of gibberellic acid on pasture and animal production in winter. Aust. J. Agric. Res. 13: 400-13.

Heinrichs, D.H., and Morley, F.H.W. (1962). - Quantitative inheritance of creeping-root in alfalfa. Canad. J. Genet. and Cytol. (In press).

Heinrichs, D.H., Lawrence, T., and Morley, F.H.W. (1962). - Breeding for improvement of quantitative characters in Agropyron intermedium (Host.) Beauv. by the polycross method. Canad. J. Plant Sci. (In press).

Lloyd Davies, H., and Bennett, D. (1962). - Studies on the oestrogenic potency of subterranean clover (Trifolium subterraneum) in south Western Australia. Aust. J. Agric. Res. (In press).

McManus, W.R., Arnold, G.W., and Hamilton, F.J. (1962). - Improved methods in oesophageal fistulation of sheep. Aust. Vet. J. 38: 275-81.

Moore, R.M., Arnold, G.W., Hutchings, R.J., and Chapman, H.W. (1961). - Poisoning of Merino sheep on Phalaris tuberosa L. pastures. Aust. J. Sci. 24: 88.

Morley, F.H.W. (1961). - Subterranean clover. Advanc. Agron. 13: 57-123.

Morley, F.H.W. (1962). - Pasture plant breeding and animal production. J. Aust. Inst. Agric. Sci. 28: 3-7.

Morley, F.H.W. (1962). - Statistics and plant selection. Proc. Symp. on Statistical Genetics and Plant Breeding, 1961. (Raleigh, N.C.). (In press).

Morley, F.H.W., Davern, C.I., Rogers, V.E., and Peak, J.W. (1962). - Natural selection among strains of Trifolium subterraneum. In "The Evolution of Living Organisms", (Ed. G. Leeper, Melb. Univ. Press). pp. 181-90.

MINERAL NUTRITION INVESTIGATIONS

This unit is housed in the School of Agriculture, University of Melbourne and its research is aimed at understanding the chemical and physical forms and reactions of elements in the cycle: soil-plant-animal. Much of the research is concerned with silicon in this cycle but long-term studies are concerned with the availability of manganese and molybdenum to plants in soils.

In the research on silicon the following people have collaborated - Sir Samuel Wadham, Professor Emeritus of the University of Melbourne; G. Baker, Mineragraphic Investigations Section, C.S.I.R.O.; G.S. Christie, Associate Professor in Pathology and Miss Angela A. Milne, Principal, University Women's College, University of Melbourne, an Honorary Research Associate of the Division. The Division of Animal Health, C.S.I.R.O., Parkville, has provided facilities for some of the research on sheep.

Properties of solid silica from plants

L.H.P. Jones and Angela A. Milne

The solid silica has been isolated from the vegetative parts of oats using wet ashing and dry ashing to destroy organic matter. Silica isolated by wet ashing is representative of the silica of the plant. Its formula is: $Na_{0.0001}$, $K_{0.0010}$, $Mg_{0.0001}$ $Si_{0.9997}$ O_2 0.520 H_2O; it is entirely opal with refractive index ranging from 1.427 to 1.440 and surface area of 14.4 m2/g. Dry ashing produces changes in the silica of the plant. Much greater amounts of sodium, potassium, calcium and magnesium are combined in insoluble forms with accompanying changes in the physical properties of the silica, notably the crystallization of a small proportion of the opal to cristobalite, an increase in refractive index and a large decrease in surface area.

Distribution of silica within the plant

L.H.P. Jones and Angela A. Milne in collaboration with S.M. Wadham

The solid silica of the oat (from root, internode, node, leaf-sheath, leaf blade, empty glume, lemma and seed) has been studied with the microscope using ordinary and polarized light

and phase contrast. The silica was separated by wet ashing and by dry ashing. The wet ashing involved digesting the plant material with nitric and perchloric acids to destroy organic matter and by taking special steps during the ashing and subsequent mounting it was possible to obtain large particles. These particles represent areas of cells which are attached together as they were in the plant tissues and in them the finest details of structures are preserved. During the more commonly used dry ashing these details are lost.

Studies of the wet-way silica and the corresponding plant tissues reveal that the walls of all types of outer epidermal cells, except cork cells, are impregnated with silica. Walls of cells in the hypodermal layer, vessels and fibres are also impregnated as are those of tracheids in the roots. The impregnating silica was invariably opal and some fine details of the structures suggest that it was deposited in intimate association with the cell wall.

The amounts of opal vary widely in the various parts. Thus, on a dry matter basis there was 9.03 to 13.47 per cent. in the glumes which was about twice as much as in the leaf; the leaf itself contained about three times as much as both internode and roots, fourteen times as much as the node and forty times as much as the seed.

Silicic acid in soils

L.H.P. Jones and K.A. Handreck

Plants absorb silicon as the simple molecule silicic acid (H_4SiO_4) and its level in the soil solution is therefore of fundamental importance. It has been found to remain fairly constant in any one soil but to range from 10 to 50 p.p.m. SiO_2 between soils; this range is far below the saturation levels of 120 to 150 p.p.m. SiO_2 at ordinary temperatures. Further studies have been carried out on the mechanisms responsible for the variation between soils and for the difference between the levels in the soil solution and those in the saturated solution.

The uptake of silica by plants in soils

L.H.P. Jones and K.A. Handreck

The work on silicic acid in soils has led to pot experiments in which the uptake of silica by oats has been studied under varying soil conditions. The conclusions to be drawn from these experiments will rest on analysis of the plant material for

total silica.

Silicon in sheep

L.H.P. Jones and K.A. Handreck

Grazing animals inevitably ingest large quantities of silicon both as silicic acid and as solid silica. This has led to studies of the fate of silicon in the sheep.

Silicic acid is absorbed from the alimentary tract, it circulates in the blood stream and is excreted in the urine. The levels in the urine of grazing sheep have been found to exceed saturation and to depend on the pasture species. The relationships between dietary silica and the excretion of silicic acid are therefore being studied under controlled conditions.

The solid silica, except for occasional particles, all passes along the alimentary tract to emerge in the faeces and the relationships between dietary and faecal silica are being studied under controlled conditions.

Silica Urolithiasis

L.H.P. Jones and Angela A. Milne in collaboration with G. Baker

Chemical and mineralogical studies of uroliths from sheep are continuing. The silica of all specimens examined has been identified as opal and this is accompanied by varying amounts of organic matter and accessory elements.

Opal Phytoliths and mineral particles in the body of the sheep

L.H.P. Jones in collaboration with G. Baker and G.S. Christie

Particles of solid silica from plants (phytoliths) and of minerals have been found in uroliths and lymph nodes. Techniques are being developed to study the ways in which these foreign particles are absorbed, and disseminated in the body.

Straw silica glass and the ignition of plants

L.H.P. Jones and Angela A. Milne in collaboration with G. Baker

Chemical and mineralogical studies of a straw-silica-glass from a burnt haystack have been completed. In the laboratory a temperature of 1150°C was required to form a glass from plant material similar to that of the haystack. At this temperature some sodium and potassium were lost by volatilization and this resulted in the glass having a lower ratio of $\frac{Na_2O + K_2O}{SiO_2}$ than the plant material. The straw-silica-glass also has a lower ratio which may be similarly explained.

The availability of manganese to plants

L.H.P. Jones

The long-term studies of the availability of manganese to plants have been continued by means of pot experiments on two manganese-deficient soils from the south-east of South Australia. One of these studies is concerned with the reversion of added manganese from available to unavilable forms, and the other is concerned with the residual effect of lime on the availability of manganese. In both studies availability will be assessed by analysis of the plant material for manganese.

Characteristics of molybdenum deficient soils

L.H.P. Jones

Detailed laboratory studies of a wide range of molybdenum deficient soils have been supplemented by pot experiments designed to assess the availability of molybdenum to plants in these soils. Availability will be assessed by analysis of the plant material for molybdenum.

PUBLICATIONS

Jones, L.H.P., and Milne, A.A. (1962). - Studies of silica from the oat plant. I. Chemical and physical properties of the silica. Plant and Soil. (In press).

Jones, L.H.P., Milne, A.A., and Wadham, S.M. (1962). - Studies of silica from the oat plant. II. Distribution of the silica in the plant. Plant and Soil. (In press).

PASTURE INVESTIGATIONS - WESTERN AUSTRALIA

The Western Australian group of the Division is concerned with both basic and applied problems of pasture research in a Mediterranean region. The region itself is characterized by an intense Mediterranean climate, predominantly annual-type pastures, soils of light texture (frequently of very low inherent fertility) and sheep rather than cattle as the grazing animal.

The fields of activity include testing and preliminary evaluation of plant introductions; studies of perennial grasses, particularly in connection with water relations; the physiological ecology of annuals; pasture plant nutrition; pasture utilization; clover infertility; and soil fertility.

In recent years several plant species have shown particular promise. These include Hyparrhenia hirta (South African blue stem), Bromus mollis (soft brome), the Carnamah strain of subterranean clover and a number of new clovers such as Trifolium cherleri and Trifolium hirtum (rose clover). These are now being explored intensively from various aspects, but already it seems likely that most of them have a useful part to play in enhancing pasture production. In particular, the new work on the deep sands of the Swan Coastal Plain, and on legumes for low rainfall areas deserve mention.

PERENNIAL GRASSES

Phalaris tuberosa and Ehrharta calycina

A.W. Humphries

Studies on adaptation of these two grasses in the Kojonup environment are nearing completion. Results from the major experiment on 14 soil types are still being collated. In general, plant mortality over the first summer was greater in Phalaris than in veld grass. And it seems that Phalaris is unable to establish a deep root system unless fertility is reasonably high. Again, Phalaris yielded relatively well on soils prone to poor aeration. Availability of the three major nutrients (N, P and K) as indicated by plant uptake showed virtually no relation to the amounts present in the surface soil.

Hyparrhenia hirta

A.W. Humphries, F.J. Roberts and J. Walker

Seedling establishment was rather unsatisfactory in an experiment involving several strains of H. hirta on four soils of the Swan Coastal Plain. Nevertheless, strain N43 has persisted well on all sites, while N1 was quite good; N17 was outstanding on a poor deep white sand and appears to be extremely drought resistant.

Seedling establishment difficulties were also encountered on the seven sites in the wheat-belt trial, due presumably to unusually low winter temperature. Replacements planted in late August established successfully, and at the end of the 1961/62 summer the standard N1 strain appeared the most vigorous and productive. Subsidiary plots of Eragrostis curvula suffered no losses during the winter.

The influence of water-table depth on the growth of H. hirta is being examined in large containers. During the first summer (1961/62) cumulative yields were highest with a water-table at 110 cm.; yields were much lower (and about equal) at 230 cm. and 350 cm.; while the controls with no water-table present showed a further reduction.

PLANT ESTABLISHMENT ON DEEP SANDS

Fine particle size amendments

F.J. Roberts and A.W. Humphries

The establishment of pasture plants on deep sandy soils often presents unique problems, especially in water relations. Three fine particle size amendments - ground silica, clay and flyash - were examined in 1961. Incorporation of about two per cent. of fine material into the top three inches of soil successfully overcame the non-wetting and germination problems, and led to increased yields of the test plant (subterranean clover). Clay and flyash were outstanding, probably because of associated benefits from extra nutrients.

The present trial will be continued. A more comprehensive experiment involving compaction treatments is planned for 1962.

SPECIES AND STRAIN STUDIES WITH ANNUALS

Subterranean clover

R.C. Rossiter and G.B. Taylor

Sward studies on the growth and adaptation of early strains under low rainfall conditions - conducted jointly with A.J. Millington, University Institute of Agriculture - are continuing. The earlier finding of low seed production for the Dwalganup strain was supported. However, in 1961 the very early flowering Carnamah strain was generally equal to, or better than Geraldton for seed yield. Results from harvests taken during the seed maturation period pointed to the superiority of Carnamah in seasons which finish early. The relative merits of Carnamah and Geraldton will probably depend on seasonal conditions, especially in the spring period, and both strains may prove useful on light-textured soils of low rainfall.

Several strains of T. subterraneum and T. israeliticum supplied by F.H.W. Morley, were grown at Perth using two dates of sowing. None were as early flowering as Carnamah.

The programme on long-term adaptation under higher rainfall at Kojonup is nearing completion. No major changes have yet appeared in the strain mixture trial: many strains continue to co-exist satisfactorily under grazing. The situation with respect to the three strains Dwalganup, Yarloop and Bacchus Marsh, under continuous grazing, is virtually the same as stated in the last report. Wool production on the Dwalganup plot was again lower than on either Yarloop or Bacchus Marsh. Differences in animal performance seemed to be related primarily to lower dry matter intake of mature herbage on the Dwalganup plot. From detailed sampling over the 1961/62 summer period, there was no indication of any statistical significant losses of clover burr. These data, together with those from earlier years, point to negligible consumption of burr on the Yarloop and Bacchus Marsh plots, where accessibility to the animal is greater than on the Dwalganup plot.

Results of studies on the influence of defoliation, light intensity and phosphate supply on flowering, will be ready for the next report.

Other Trifolium species

R.C. Rossiter, E.T.Bailey and G.B. Taylor

The two adaptation trials in which strains of T. cherleri, T. hirtum (rose clover) and T. subterraneum, will be tested under grazing conditions in the wheat-belt, have commenced. Three subsidiary trials will be put down in 1962.

An experiment with single strains of the above three clovers, each at three sowing rates and with and without a cereal companion crop, was conducted at Lake Grace. Companion crop effects were negligible. There were, however, large differences in seed yield between the three clovers and highly significant species x sowing rate interactions. At all three sowing rates, the Geraldton strain of subterranean clover was clearly inferior to the two new clovers (Kondinin rose clover and 13930 T. cherleri).

Further work is planned with these clovers to examine soil-plant water relationships during the period of reproductive development.

Soft brome grass

R.C. Rossiter and J. Walker

The grazing trial at Kojonup is nearing completion, after demonstrating the capacity of soft brome grass to persist satisfactorily under moderately heavy grazing and even at a stocking rate of four sheep/acre.

The intensive examination of strains within the species, mentioned in the last report is nearing completion. From the original collection, eight strains were selected for detailed study during 1961. Results from the sward trials showed that even under moderately low rainfall at Muresk (17 in.) seed yields were very high in all except the three latest maturing strains. A sward trial will be conducted in 1962 under even lower rainfall to explore further the potential of this pasture grass.

Some studies on factors influencing flowering are in progress. It has been shown that addition of fertilizer N hastens flower initiation by six days (earliest strain) to thirteen days (latest strain).

ECOLOGY OF ANNUAL-TYPE PASTURES

Effect of phosphate

R.C. Rossiter

The long-term experiment on botanical composition has been concluded. Effects of P supply on total growth have been large and appreciable seasonal effects were noted. However, the mean effects of phosphate - over the 13-year period - on percentage subterranean clover, were relatively slight, falling from a maximum of 46 per cent. with ½ cwt/acre/year superphosate to 30 per cent. with 4 cwt/acre/year. In general, capeweed and ripgut brome grass increased and erodium and silver grass declined with increasing P supply.

Long-term seasonal effects

R.C. Rossiter

This experiment is nearing completion after ten years. Reasons for the seasonal effects on botanical composition changes are still obscure: they do not seem to be related to date of seasonal opening. Again in 1961 there was no clear evidence of increased clover content with an increase in stocking rate from two sheep/acre to four sheep/acre.

PASTURE PLANT NUTRITION

Mechanisms binding phosphate in soil

P.G. Ozanne and T.C. Shaw

Recent experiments have shown that on sandy soils a considerable part of the annual dressing of superphosphate may be leached down below the principal root zone of pastures. Measurement of phosphate leaching in field trials is a laborious and time consuming procedure. To allow the examination of the phosphate retaining capacity of a large number of soils, a simpler laboratory technique has been used.

Working with a wide range of soils it was found that over 90 per cent. of the variation in phosphate sorption was accounted for by corresponding variations in their content of readily soluble aluminium and iron. However, there are extensive areas of sandy soils low in sesquioxides in Western Australia.

Evidence is being examined to find whether building up the organic matter content of light soils also increased their power to bind applied phosphate.

Movement of radio-active phosphorus and sulphur in soil

P.G. Ozanne and D.J. Kirton

It has become apparent from laboratory tests, as well as from field experiments that the extensive areas of grey sands on the coastal plain have little power to retain applied phosphate. To examine the fate of fertilizer applied to these sands, commercial superphosphate was labelled with both radio-active phosphorus-32 and sulphur-35. Using this technique rapid and extensive losses of phosphorus and sulphur were clearly shown. The dual labelling of superphosphate greatly facilitated the study of the two essential elements phosphorus and sulphur supplied in this fertilizer.

Residual value of superphosphate

N.J. Barrow

A series of field trials has been established on pastures which range from one which has only recently been sown to one which has been fertilized for more than 30 years. The aim of these trials is to measure the decline in yield which occurs when the pasture is no longer fertilized with phosphorus and sulphur.

Nitrogen stress

E.A.N. Greenwood and Z.V. Titmanis

Studies in the measurement of N stress in pasture grasses have been extended from pot culture to the field. Extremely large and rapid increases in N stress occur during the winter months on the Swan Coastal Plain, and on light soils at Kojonup, due to leaching of native and fertilizer N. Further evaluation has been made of the leaf concentration of free alpha amino N as an index of N stress. This N fraction, the accurate determination of which is much quicker than either total N or nitrate N, appears to be as reliable a predictor of N stress in the field as in pot investigations. Diurnal variations in this N fraction can be neglected if sampling is performed between 09.00 and 12.00 hours. (This cannot be said of nitrate N).

A comparative study with wheat, Wimmera rye grass and soft brome grass, at a young state of growth, has shown that a given concentration of free alpha amino N represents the same degree of N stress in all species.

An attempt to ascertain the role of N fertilizer in the subterranean clover areas of W.A. has commenced. The effects of fertilizer N, as distinct from clover N, on plant and animal production, is being studied.

Studies on soil potassium

N.J. Barrow

Measurement of exchangeable potassium is not always an adequate guide to potassium availability. What is needed is a measure of how firmly the potassium is held, an indication of how this changes as potassium is added and removed, and a measure of the rate at which potassium can be supplied from slowly available form. It is intended to test the possibility that procedures involving equilibration with dilute electrolytes can be used to provide these measures. Accordingly, a wide range of Western Australian soils has been collected and their potassium status is being assessed in the glasshouse. This will be tested against estimates of potassium status made by chemical means. It is intended that in the course of this work, much will be learned about the potassium status of W.A. soils. However, the long-term aim is to find chemical procedures which will indicate potassium status more clearly and which will have general application.

Potassium uptake by pasture species

P.G. Ozanne and D.J. Kirton

Due to the occurrence in W.A. of extensive areas of light soils low in potassium, a study is being made of species characteristics which permit pasture growth under conditions of low potassium supply. Big differences in the depth and extensiveness of root development between pasture species have already been found. Further studies have shown that the shallow rooting habits of some pasture plants are emphasized when the plants are shaded.

Seedling emergence and development in potassium deficient soil have been found to vary markedly between different annual pasture species. The large-seeded W.A. blue lupin showed

particular ability in root development by rapidly penetrating to 3 feet in a sand almost free of available potassium. This characteristic may well be connected with the marked success of lupins on rather infertile sandy soils.

Cobalt requirement of subterranean clover

P.G. Ozanne and T.C. Shaw

In last year's report a description was given of a cobalt response obtained with subterranean clover in the field. This result has now been confirmed in a second field trial. The results of these two experiments show that yield increases of 30 per cent. or more may be obtained by the use of cobalt on first year stands of clover. In both trials the critical level of cobalt in the plant material was similar and less than half that required by animals. Cobalt sulphate applied at 2 oz/acre overcame the clover deficiency, but 10 oz/acre increased the cobalt concentration in the plant material to a safe level for grazing animals.

Chlorine deficiency in subterranean clover

P.G. Ozanne

Earlier experiments have shown that under acute chlorine deficiency the development of runners and flowers on subterranean clover is prevented. It has now been found that swards growing under mild chlorine stress still show reduced burr formation, even though no foliar symptoms are evident.

PASTURE UTILIZATION

Stocking rate

H. Lloyd Davies

The striking results with Merino wether sheep mentioned in the last report, have been further substantiated. Although the decline in wool production per head was not quite so marked as in the two previous years, overall wool production was highly satisfactory, ranging from 12.3 lb/acre at 1 sheep/acre to 55.0 lb/acre at 5 sheep/acre. There were, however, some tender fleeces at the highest stocking rate. The effect of N fertilizer

at the 5 sheep/acre rate was less pronounced than last year.

Time of lambing

H. Lloyd Davies

The large field experiment involving 3 lambing times x 3 stocking rates will be completed at the end of 1962. In 1961, as in the two previous years, the proportion of lambs marked to ewes mated was markedly reduced with winter lambing: mean values for autumn, winter and spring lambing, were 65 per cent., 51 per cent., and 69 per cent. respectively. The decline in lambing percentage with increased stocking rate was less pronounced than previously. Results confirm the earlier findings that failure of ewes to lamb is the major source of wastage in the breeding flock.

Liveweight gains of the lambs also conformed to the pattern established in previous years. It now seems clear that with August lambing, high stocking rates can be supported without deleterious effects on lamb growth rate.

In this experiment, as well as in the stocking rate trial above, increased rates of stocking were not associated with increased proportions of subterranean clover in the pasture. Moreover, in the present experiment, subterranean clover has contributed 40 per cent. of the species available on any plot since July 1960. Nevertheless, the limited evidence presently available points to clover-induced infertility as an important factor under these conditions.

Metabolism studies

H. Lloyd Davies

Earlier studies (in pens) showed that voluntary dry matter intake was reduced with pastures of high water content: total wet matter intake seemed to be constant. Preliminary work with capeweed showed that partial dehydration - from 9 per cent. to 18 per cent. dry matter - had virtually no effect on voluntary dry matter intake. An experiment in which water was introduced into the rumen *per fistulam* indicated that water *per se* does not appear to play any vital role in voluntary dry matter intake.

Weaner investigations

H. Lloyd Davies

Further evidence is now available from the field experiment mentioned in the last report supporting the claim that preweaning nutrition is the most important factor affecting welfare (and especially mortality) during the summer. Recent observations suggest that the two elements selenium and cobalt may be implicated.

CLOVER INFERTILITY STUDIES

Bio-assay of subterranean clover

H. Lloyd Davies, A.B. Beck and D. Bennett

The oestrogenic activity of three strains - Dwalganup, Yarloop and Mt. Barker - was measured using both sheep and mouse bio-assay: uterus weight increase in ovariectomized animals was used as a measure of activity. With sheep, both Dwalganup and Yarloop were highly potent, whereas Mt. Barker showed little activity. With mice, Dwalganup and Yarloop were of comparable potency, although the observed oestrogenic potency was higher than with sheep; and Mt. Barker showed about half the activity of Dwalganup.

Further bio-assay work will be undertaken to clarify present anomalies. Field trials are being set up to obtain some reliable information on the relation between subterranean clover strain and the infertility syndrome.

Chemical assay of clover

A.B. Beck

Preliminary work has been done using chromatographic methods of separating the oestrogenic compounds in subterranean clover. Results indicate that it should be possible to separate formononetin and biochanin A; the separation of genistein and coumestrol, however, is proving difficult. The chemical work is proceeding.

SOIL FERTILITY INVESTIGATIONS

Short-term effects of subterranean clover

E.R. Watson

Results of a comprehensive experiment, now concluded, have shown a linear relationship between soil nitrogen accumulation and age of pasture over the first five years of life. Each additional year of clover pasture gave an additional yield of two bushels/acre of wheat grain. However, soil nitrogen build-up (due to clover pasture) accounted for the differences in cereal production following the clover ley. The clover pastures had little effect on the percentage of nitrogen in the wheat grain or on baking quality.

Effects of phosphate

E.R. Watson and P. Lapins

The long-term trial (commenced in 1952) on effects of phosphate level is nearing completion. From the pasture data now available, linear relationships are evident between soil nitrogen build-up and accumulated production of the clover component of the sward. Regression coefficients for the 1 cwt/acre/year and the 3 cwt/acre/year phosphate treatments are similar in magnitude, but less than that for the 1/3 cwt/acre/year treatment. The relationship between soil nitrogen and clover production accounts for results from another long-term trial with various phosphate levels in which the percentage of soil nitrogen reached an asymptote at 15 cwt/acre superphosphate at the end of a 13-year period.

Role of clover herbage

E.R. Watson and P. Lapins

In the last report attention was drawn to the unimportant role of sheep per se in soil nitrogen build-up. It now seems that the clover herbage, whether consumed by sheep or mown and returned (after dehydration) may play a small and unimportant role. Studies now in progress indicate that clover roots and "butts" can account for the observed soil nitrogen build-up. Special attention is therefore being directed to the possible sources of nitrogen loss from the system.

Urine-nitrogen losses

P. Lapins and E.R. Watson

The possibility of nitrogen losses from urine voided by grazing sheep has been under examination in recent years. Over the past two years, the problem was investigated with the aid of two lysimeters on two soil types sown to Wimmera rye grass. The fate of urine-nitrogen was followed using four different times of application. Over the two-year period leaching losses were generally low, except with the December application of urine, where the loss was about 14 per cent. of the amount applied. Unaccounted losses, presumably in the gaseous form, amounted to 45 per cent. to 60 per cent. with no clear and consistent effect of soil type.

PUBLICATIONS

Asher, C.J., and Ozanne, P.G. (1961). - The cation exchange capacity of plant roots, and its relationship to the uptake of insoluble nutrients. Aust. J. Agric. Res. 12: 755-66.

Asher, C.J., and Ozanne, P.G. (1962). - Nutrient uptake in relation to root development. Third Aust. Conf. Soil Sci. Paper No.107.

Barrow, N.J. (1961). - Mineralization of nitrogen and sulphur from sheep faeces. Aust. J. Agric. Res. 12: 644-50.

Barrow, N.J. (1961). - Phosphorus in soil organic matter. Soils and Ferts. 24: 169-73.

Barrow, N.J. (1962). - Mineralization and immobilization of sulphur. Third Aust. Conf. Soil Sci. Paper No.90.

Barrow, N.J., and Lambourne, L.J. (1962). - Partition of excreted nitrogen, sulphur and phosphorus between the faeces and urine of sheep being fed pasture. Aust. J. Agric. Res. (In press).

Barrow, N.J., and Jenkinson, D.S. (1962). - The effect of water-logging in fixation of nitrogen by soil incubated with straw. Plant and Soil. (In press).

Beck, A.B. (1961). - Observations on the copper metabolism of the domestic fowl and duck. Aust. J. Agric. Res. 12: 743.

Beck, A.B. (1961). - The liver copper levels of foetal and newly-born marsupials and whales. Aust. J. Sci. 24: 245.

Beck, A.B. (1962). - The levels of copper, molybdenum and inorganic sulphate in some Western Australian pastures. Aust. J. Exp. Agric. Anim. Husb. 2: 40.

Davies, H. Lloyd (1962). - Studies in lambing time in relation to stocking rate in south Western Australia. Proc. Aust. Soc. Anim. Prod. (In press).

Davies, H. Lloyd (1962). - Intake studies in sheep involving high fluid intake. Proc. Aust. Soc. Anim. Prod. (In press).

Davies, H. Lloyd, and Bennett, D. (1962). - Studies on the oestrogenic potency of subterranean clover (Trifolium subterraneum) in south Western Australia. Aust. J. Agric. Res. (In press).

Freney, J.R., Barrow, N.J., and Spencer, K. (1962). - Sulphur in soil. A review. Plant and Soil. (In press).

Greenwood, E.A.N. (1962). - The estimation of nitrogen requirements of gramineous crops. Third Aust. Conf. Soil Sci. Paper No.75.

Humphries, A.W., and Bailey, E.T. (1961). - Root weight profiles of eight species of Trifolium grown in swards. Aust. J. Exp. Agric. Anim. Husb. 1: 150-2.

Humphries, A.W. (1962). - The growth of some perennial grasses in waterlogged soil. I. The effect of waterlogging on the availability of nitrogen and phosphorus to the plant. Aust. J. Agric. Res. (In press).

Humphries, A.W. (1962). - The influence of soil characteristics on the growth of two perennial grasses. Third Aust. Conf. Soil Sci. Paper No.109.

Kirton, D.J. (1962). - The effect of time on the fixation of applied phosphorus in soils. Third Aust. Conf. Soil Sci. Paper No.70.

Ozanne, P.G. (1962). - Pasture responses on a cobalt deficient soil. Third Aust. Conf. Soil Sci. Paper No.81.

Rossiter, R.C. (1961). - The influence of defoliation on the components of seed yield in swards of subterranean clover (Trifolium subterraneum L.). Aust. J. Agric. Res. 12: 821-33.

Shaw, T.C. (1962). - Phosphate sorption capacity of a number of unfertilized soils in Western Australia. Third Aust. Conf. Soil Sci. Paper No.78.

Steinbergs, A., Iismaa, O., Freney, J.R., and Barrow, N.J. (1962). - The determination of total sulphur in soil and plant material. Analyt. Chim. Acta. (In press).

Watson, E.R. (1962). - The influence of subterranean clover pastures on soil fertility. I. Short-term effects. Aust. J. Agric. Res. (In press).

Watson, E.R., and Lapins, P. (1962). - The effect of grazing, cutting and removing; cutting and returning clover pasture on soil nitrogen build-up and N uptake by subsequent wheat crops. Third Aust. Conf. Soil Sci. Paper No.86.

PASTURE INVESTIGATIONS - DENILIQUIN N.S.W.

The Regional Pastoral Laboratory at Deniliquin is situated in the important Riverina region of New South Wales and is representative of a large area of semi-arid grazing land. It is also an irrigation district and the availability of water greatly enhances its value as a centre for agricultural research. The laboratory and its associated Falkiner Memorial Field Station was established for the purpose of investigating the establishment of highly productive pastures under irrigation on the heavy-textured problem soils of the Riverina, and a study of the ecology of dry-land pastures with a view to maintaining or if possible, improving their stock carrying capacity.

The general aim is to provide answers to agricultural problems at a level which, wherever possible, allows generalizations that are valid beyond the particular set of circumstances - in other words, for a range of comparable environments. Thus problems of cultivation and irrigation are pursued with methods of soil physics and soil micrometeorology; studies of pasture production and utilization are supported by a plant physiological analysis of the energy balance of the systems involved; studies of nutrient deficiencies are related to the nutrient balance in plant and soil; the interactions of dry-land native and introduced weed species are studied in the light of moisture and nutrient balance in different plant associations throughout their complex and closely inter-woven life cycles.

WATER AND PLANT GROWTH

Lysimeter experiments

B.D. Millar

Work has continued with small weighable lysimeters used to assess Ladino clover production and water use under frequent versus infrequent irrigation. Both growth and water loss decreased below potential rates as soil moisture approached the wilting point. In an experiment in autumn when evaporation was low, these effects were far less pronounced. These results are being analysed especially in relation to the usual physiological measures of water stress.

The role of advected energy in increasing water use has been assessed on one occasion to date. Advective energy accounted for more than half the latent heat of vaporization of water lost during the run. In view of the importance of this effect in the semi-arid zone a pasture has been established in an area of dry land to extend the study.

Effect of frequency of irrigation in the field

L.F. Myers and R.I. Baxter

While more detailed studies of the effects of water supply on plant growth are proceeding an assessment of water use - production relationships are being attempted in the field. These empirical trials are designed to provide an estimate of many factors related to particular sites which cannot be made in any other way. Effects of soil moisture characteristics, root distribution, deep percolation losses, advective effects and all their interactions make prediction to the field level difficult. Direct measurement of irrigation frequency on water use and water use efficiency are in progress on widely divergent sites. In a preliminary trial irrigations were applied to a white clover - paspalum pasture at a frequency of 3, 4, 6, 8 and 12 per cycle of 7 weeks. Timing of the irrigations was based on evaporation interval from an open tank. The total amount of water used was constant for 6, 8 and 12 irrigations. Optimum efficiency and maximum production was attained with 6 irrigations (2 inches evaporation interval). At this site close to maximum production per unit of applied water was achieved by a fairly wide range of irrigation frequencies. Any method of determining the time to irrigate which was accurate to $\pm$ 25 per cent. would have been quite adequate for this site during the height of the summer.

Persistence of lucerne under flooding

Veronica R. Rogers and R.H. Sedgley

A one-year old stand of lucerne growing on a heavy soil (Riverina clay) was flooded for periods of one to ten days during February. An uncut stand was reduced by 5 per cent. by 10 days flooding; in a stand cut before flooding 70 per cent. of plants died. This result has a bearing on the common practice of irrigating grazed lucerne immediately the animals are removed.

SOIL FERTILITY AND PLANT NUTRITION

Soil nitrogen accumulation, Soils

C.R. Kleinig

The long-term field trials are continuing to yield interesting results and more detailed work has begun. The trends at the end of the third year suggest that a major factor influencing nitrogen accumulation is the clover yield of the pasture irrespective of species, time of maximum growth or the amount of associated grass.

Zinc responses on calcareous soils

C.R. Kleinig with J. Loveday (Division of Soils)

The calcareous grey and brown soils of heavy texture in the Coleambally Irrigation Area are being developed for irrigated pastures. After levelling of these soils for irrigation, up to 50 per cent. of the land surface may be exposed subsoil. Low production on this subsoil has been found to be due to zinc deficiency. The lake bed soils of the Balranald district have also been found to be zinc deficient. The New South Wales Department of Agriculture are planning demonstrations and assessment trials based on this work.

Similar work to assess minor element deficiencies is continuing.

Effects of nitrogen supply on rice yields

C.R. Kleinig

The percentage of fertile florets can be a major factor in rice yields. High nitrogen levels were found to delay flowering and the number of fertile florets fell as flowering was delayed. Both time of flowering and nitrogen supply are separately involved in this effect. The higher the nitrogen level at a particular flowering time the lower the percentage of fertile florets. Less than 2 per cent. "fill" was recorded in the most severe treatment.

Competition between rice and Echinochloa crus-galli

C.R. Kleinig

Echinochloa crus-galli is a serious weed in rice due to its more rapid emergence and development than rice. A direct relationship between yield of rice and density of Echinochloa tillers immediately prior to flooding was obtained in the field for any particular level of nutrient supply. In pot culture the application of N, P and S favoured the competitive ability of Echinochloa to a much greater extent than that of rice. This was confirmed under field conditions where the higher the application of nitrogen or superphosphate the greater the detrimental effect of Echinochloa on yield of rice for any particular density of infestation. With an Echinochloa density of 6 tillers per sq. link rice yields fell with increasing supply of nitrogen, phosphorus and sulphur.

SOIL PHYSICAL CONDITIONS AND PLANT GROWTH

Long-term effects of gypsum and deep tillage on pasture growth

R.H. Sedgley

The yield increases due to deep tillage and gypsum application reported previously were maintained in the third year. Gypsum broadcast at heavy rates (6 tons/acre) increased yields by 2,000 to 3,000 lbs dry matter per acre and deep tillage by a further 1,000 lbs/acre. Field and laboratory work suggest this effect is a physical one and the yield increases can be ascribed to the extra water stored in the soil of the treated plots.

Further field experiments on white clover-paspalum perennial pastures following long-term effects of dissolved and broadcast gypsum under grazing and cutting have been laid down.

Effect of methods of application of gypsum on pore space changes during emergence

R.H. Sedgley and R.H. Crockford

Leaching experiments in the laboratory indicated that the rate of solution of solid gypsum was considerably faster than had been previously assumed. This led to re-examination of the

possibility of low rate broadcast treatments, as an alternative to the gypsum solution technique which has been successfully used for establishing pastures on heavy soils in the Deniliquin region.

Using a fine seed-bed, gypsum broadcast at a rate of a half ton per acre gave only slightly inferior emergence to a rate of a quarter ton per acre of dissolved gypsum. In these experiments plots which had received the low rate broadcast treatments maintained high porosities in the seed-bed for a longer period than any of the dissolved treatments.

This work is being continued in field trials conducted in co-operation with the New South Wales Department of Agriculture.

Pasture response to gypsum in terms of animals

L.F. Myers

Changes in soil and pasture following gypsum treatment are being determined in a 4-year grazing experiment.

The experiment (sown 8th March 1961) has been grazed at 8 sheep per acre since November. Emergence of seedlings was increased by 4 and winter growth by 50 per cent. by the use of gypsum. Liveweight loss from November to March was least on the gypsum plots and probably reflected the lower clover seed yields of the control plots. The results of the seed harvest are not yet available. Emergence of seedlings in the second year following the first autumn irrigation in March were 2 plants per square link on the controls and 22 plants per square link on the gypsum treated plots.

SPECIES TESTING FOR IRRIGATED PASTURES

Progress in research into nutritional and physical limitations of the soils has allowed attention to be redirected to the limitations of our pasture species. Species which will fix more nitrogen, and grasses which exploit this nitrogen in the most efficient way for annual production are being more actively sought. It is becoming increasingly clear that species can only be ranked in order of desirability when the purpose for which they are required is defined and they are tested under a relevant management system.

Legumes

C.R. Kleinig

White clover (Trifolium repens) yields well on light soils but on heavy soils wilts between weekly irrigations in hot weather. Lotus corniculatus does not show wilting under these conditions and outyields white clover. Flooding for 24-30 hours at each irrigation increased white clover yields, decreased lucerne yields and had no effect on Lotus. Although well nodulated, all three species responded to applied nitrogen. In the case of white clover this response was related to phosphorus level.

Phaseolus lathyroides and Vigna marina are promising summer growing legumes, especially in hot summers. Both are killed by winter frosts but regenerate from seed. Lotononis bainesii yields well in the first year and survives the winter but yields decline in the second year.

Grasses

L.F. Myers and V. Squires

The experiment reported last year has been continued. Second year yields are similar to those of the establishment year in spite of a marked fall in plant density in some species.

Flooding treatment began in December on four of the original eight replicates as planned. The flooding treatment is milder than originally intended and maintains free water on the surface for only 24 hours. Yield increases of some species, particularly paspalum, due to flooding weekly compared with normal irrigation weekly suggests water limits production of some species more than others. Nitrogen yield, and presumably uptake of nitrogen, also changes differentially with flooding. The experiment is proceeding.

This trial, besides showing up promising new summer grasses, has demonstrated the importance of quite small differences in technique in the ranking of species for a particular purpose.

Lucerne varieties and management

Veronica R. Rogers

The persistence of a number of varieties was determined on irrigated swards after 5 years of heavy and fairly frequent grazing. The plant densities for the varieties were:-

Lahontan	14	plants	per	square	link
Hunter River	9	"	"	"	"
du Puits	2	"	"	"	"
Hairy Peruvian	2	"	"	"	"
African	3	"	"	"	"

Two varieties, Hairy Peruvian and Hunter River were cut at the preflowering stage for two years. In the following season they were cut at full flower, but this has not restored production. The low production is due in part to lower density of the stands and greater weed invasion compared with plots cut for the whole period at full flower.

DRYLAND INVESTIGATIONS

The maintenance and improvement of the extensive dryland communities (which support the majority of Australia's sheep) is an important subject for research. Quite small increases in production could lead to significant contributions to the wool industry because of the extent of many of the communities. Research effort has been increased in this field and only the early stages of work can be described.

Establishment of Barrel medic on light soils

C.R. Kleinig

During 1960 in a favourable winter, poor emergence was improved by lime pelleting or dusting with fungicide and yield was increased by over 100 per cent. by lime pelleting or lime application. In 1961 in a dry winter though emergence was good on all treatments, yields were very poor.

Old man saltbush (Atriplex nummularia)

J.H. Leigh and O.B. Williams

The establishment, fertilizer response and growth of old man saltbush is being investigated. The grazing trial to

determine its contribution to the diet of the grazing animal has been reported previously. After initial difficulties, due to poor seasons, grazing has commenced.

Role of perennial shrubs in animal production

J.H. Leigh

Although it is generally recognized that perennial shrubs provide browse at critical times, no direct determination of their role has been attempted. A grazing trial began this year to make the assessment for Kochia aphylla (cotton bush). In addition, some exotic species from South Africa are being tested against the native shrubs for growth and persistence under dry conditions.

Potential growth rhythms of native grassland

R.I. Baxter

Monthly irrigations applied to a grassland have shown a wide divergence of response to extra water between species and seasons. A very high proportion of species both annual and perennial do not respond to additional water during the summer. A parallel trial under controlled temperature conditions seeks to establish the conditions necessary for the germination and establishment of the species in the same community.

Growth under high levels of solar radiation

J. Warren Wilson

Plants of Helianthus annuus grown in summer when radiation was very high (700 cal/cm^2/day) had net assimilation rates (E) roughly double these found in temperate and tropical regions. Relative growth rates were higher than any previously recorded.

It was thought that shading might increase E by alleviating the water deficits of leaves exposed to this intense radiation but E was reduced by shading. This was attributed to (i) high temperatures causing even the highest light receipt to be non-saturating; (ii) transpiration being determined less by radiation than by advection.

These results suggest irrigated vegetation in arid regions has, during the summer, the highest potential crop growth rate of vegetation in any part of the world.

Vegetation patterns in grassland

J. Warren Wilson and J.H. Leigh

A mosaic of vegetation in a grassland has been found to correspond to differences in level of the order of 1 to 2 centimetres. Statistical studies and other investigations are designed to determine the reasons for this curious distribution.

ANIMAL PRODUCTION

Integration of summer and winter pastures

L.F. Myers and V. Squires

The irrigation experiment used to assess animal production of subterranean clover - Wimmera rye grass pastures was terminated on its third anniversary. The sheep in this trial were under slight nutritional stress in the summer when potential wool growth rates are highest. Provision of summer green feed is being tested as a means of raising wool production. Four model farms have been set up to compare Phalaris - subterranean clover pastures alone and supplemented by Paspalum - white clover pastures at two farm stocking rates. Management systems appropriate to these model farms with more than one pasture have been evolved.

The experimental design allows a wide range of qualities and quantities of feed to be related to wool growth. Mid-side samples are taken every 28 days.

PUBLICATIONS

Daday, H., Mottershead, B.E., and Rogers, V.E. (1961). - Performance and interaction in varieties of lucerne (Medicago sativa L.). Aust. J. Exp. Agric. Anim. Husb. 1: 67-72.

Kleinig, C.R., and Loveday, J. (1962). - Responses of pasture legumes to zinc and manganese on calcareous soils in the Riverina, N.S.W. Aust. J. Exp. Agric. Anim. Husb. (In press).

Morley, F.H.W., Davern, C.I., Rogers, V.E., and Peak, J.W. (1962). - Natural selection among strains of Trifolium subterraneum. In "The Evolution of Living Organisms", pp. 181-90. (Ed. G. Leeper). (Melb. Univ. Press).

Sedgley, R.H., and Rogers, V.E. (1962). - The effect of micro-topography on the yield of irrigated lucerne on hard-pan soils. Aust. J. Exp. Agric. Anim. Husb. (In press).

Sedgley, R.H. (1962). - The effects of disruption and flocculation on porespace changes in beds of clay aggregates. Soil Sci. (In press).

Sedgley, R.H. (1962). - Physical effects of gypsum on some Riverina soils. Proc. Third Aust. Conf. Soil Sci. Paper No.55.

Warren Wilson, J. (1962). - Estimation of foliage denseness and foliage angle by inclined point quadrats. Aust. J. Biol. Sci. (In press).

Warren Wilson, P.M., and Warren Wilson, J. (1962). - Cambial regeneration in approach-grafts between petioles and stems. Aust. J. Biol. Sci. (In press).

FRUIT INVESTIGATIONS - TASMANIA

To allow for transportation to distant markets and to spread the period of consumption, the fruit industry attempts to maintain in a sound and attractive condition a delicate plant organ with a high rate of respiration and rapid rate of senescence. It aims to reduce these by lowering metabolic rate by cool storage which often fails to maintain the normal pattern of respiration so that by-products accumulate to injurious levels. The length of time before this occurs is the commercial storage life and it is desirable to be able to anticipate what this will be and to extend it to as long as possible. It is influenced by a large number of interacting factors which fall into two main groups; those which derive from the relationship between the fruit and the tree which bore it, e.g. nutrition, growth, relative state of development at harvest and seasonal climate, and those affected by the physical conditions of storage. The investigations of the unit at Hobart, Tasmania, have been directed at these factors with particular emphasis on the first group.

PHYSIOLOGY OF FRUITS IN RELATION TO DISORDERS

Cell size and cell number in relation to disorder

D. Martin, T.L. Lewis and J. Cerny

Fruit size is one of the most important factors in disorder incidence and in seeking more fundamental reasons for this, studies of cell size and number are in progress. Up to the present, efforts have been directed at the period of active cell division in the fruit. Attempts have been made to influence cell number either directly by kinins and growth active substances or indirectly by supplementary nutrients or reducing competition with the young fruit.

The kinins and growth active substances at present available have produced only small responses and better results may result from the kinin of apple fruits recently discovered by the Division. The greatest imposed increase in cell number has resulted by reducing competition by thinning (i) by chemical means using sodium dinitroorthocresylate but not by N.A.A.; (ii) hand thinning of blossoms but not of fruits in the post cell division stage. The greatest natural influence on cell number

has been cropping level in the previous season; a very heavy crop in 1956 induced a strong rhythm in crop and in cell numbers per fruit which has persisted until 1961. From this work it is now apparent that the relation of cell size to storage disorder is secondary to climatic effects of which the temperature in January and February is suspected of being important.

It is now proposed to concentrate the attack on this problem on building the reserves in the spur and bud in the previous season.

Organic metabolites in relation to climatic lesions

D. Martin, T.L. Lewis and J. Cerny

This project is directed principally on the disorder Breakdown which is suspected of being aggravated by climatic conditions. No season of high susceptibility has occurred since 1952 and no response to metabolites applied in the current season can be reported.

On the disorder Jonathan Spot, which has varied widely from season to season, no response to metabolites (except a small one to casein hydrolysate) has occurred but in addition to the relationships to seed number reported in the Aust. J. Agric. Res. a very striking correlation between seed number and seasonal incidence of Jonathan Spot has been demonstrated for a plot over the years 1956-61.

The experiments are to be continued on a reduced scale until a season of high breakdown incidence occurs. It is also proposed to investigate the possibility of augumenting the reserves in spurs and buds by post-harvest treatments.

Mineral balance in relation to disorder

D. Martin, T.L. Lewis and J. Cerny

Consistent success has now been achieved in reducing the incidence of pit by at least 50 per cent. by the use of sprays of calcium salts. The experiments in 1961/62 were aimed at (i) evaluation of the two most effective salts the nitrate and the chloride. No consistent significant difference could be found between the effectiveness of these two salts and the performance was not improved by the addition of borax and the chloride was more toxic; (ii) tests with formate: this salt was relatively

ineffective and the efficiency was not improved by the addition of glycerol; (iii) experiments on spray timing and frequency. The overall results were that for a given frequency and interval the later the spray schedule starts the better the effect and for a common starting date the more sprays in the schedule the better.

Experiments with Ca^{45} were directed at determining the effects of added calcium and magnesium on the movement of soluble calcium from the fruit to the leaves. Although the addition of magnesium to the fruits induced pit lesions there was no evidence that it accelerated the movement of soluble calcium in the fruit to the leaves or that adding calcium retarded it. Pit lesions developing in Ca^{45} treated fruits showed enhanced activity in autoradiographs.

A co-operative experiment with officers of the Department of Agriculture showed that when calcium was omitted from nutrient solutions to apples in sand culture the fruit became highly susceptible to pit.

Studies of the internal atmosphere of fruits

J. Cerny and D. Martin

This work has been expanded to include measurements of the permeability of the fruit to gases and estimations of the number of open lenticels.

The results of earlier work have been confirmed and extended. The information suggests that in the varieties Cox, Jonathan and Sturmer at least, the permeability of the fruit to direct gaseous exchange is more important than respiration rate in determining internal gas composition and that this permeability is related to the number of open lenticels. The augmented respiration rate found in fruits destined to develop Breakdown and Jonathan Spot, has been now found to occur in fruit which will develop late scald. The relation of late scald intensity to seed number found in G.S. has now been confirmed for S.T.P.

Physiology of chilling injury

T.L. Lewis

The work commenced at Purdue University with Professor Workman on the fundamental nature of chilling injury in the tomato was completed. The main finding was that exposure to

chilling immediately initiates a rise in the permeability of cells to electrolytes and a very rapid fall in the capacity of the tissue for oxidative phosphorylation. The rapidity with which these effects are produced suggested a very close linkage with physiological processes primarily affected by chilling.

The technique developed for the tomato studies shows promise of being successfully adapted to apple tissue and a start has been made on the study of the effect of chilling on the capacity for oxidative phosphorylation in varieties with a range of susceptibility to chilling injury.

A start has also been made on a study of the relation of phosphorylative activity to the climacteric.

Scald studies

D. Martin and J. Cerny

Small scale tests of methods of application of diphenylamine and Santoquin were continued.

Bulk containers

D. Martin and E.O. Miezitis

Further small scale studies on bin design in relation to ventilation in pre-cooling and stowing were carried out as part of a co-operative study with the Division of Food Preservation.

PUBLICATIONS

Martin, D., Lewis, T.L., and Cerny, J. (1961). - Jonathan Spot. Three new factors related to incidence: fruit size, breakdown and seed numbers. Aust. J. Agric. Res. 12: 1039-49.

Martin, D., Wade, G.C., and Stackhouse, K. (1962). - Bitter pit in the apple variety Sturmer in pot experiments using low levels of major elements. Aust. J. Exp. Agric. Anim. Husb. 2: 92-6.

FRUIT INVESTIGATIONS - QUEENSLAND

A low yield of marketable apples per unit area in the Stanthorpe district prompted the commencement of these investigations in 1933. It appeared at that time that the low yields were determined largely by the dwarf stature of the trees, due probably to the nature of the rootstocks used combined with low soil fertility. Rootstock trials to compare the growth and performance of trees on a series of imported clonal apple rootstock seedlings and Northern Spy and using the principal scion varieties of the district were established. These trials were extended later to include many other apple rootstock varieties including clonal woolly aphis resistant types. Rootstock trials with pears were also undertaken. Upon these basic trials fertilizer pruning treatments were superimposed and in addition, studies made of soil mineral deficiencies. During more recent years investigations have included studies of the effect of rootstocks on various attributes of quality in apples and their keeping qualities.

ROOTSTOCK TRIALS

The main trial with apple rootstocks

L.A. Thomas

This trial was planted in 1938 with two scion varieties Jonathan and Granny Smith in alternate rows. Jonathan on stocks Malling I, XII, XVI, Pomme de Neige seedlings and Spy with guard rows on Malling II and French Crab seedlings; Granny Smith on Malling XII, XVI, Pomme de Neige seedlings and Spy, with guard rows on Malling II and Malling XIII rootgrafts.

Jonathan

Stock	Girth cm. 1961	accumulated crops lb/tree 1938-62	1938-50
XII	58.0	2654	734
XVI	54.0	2609	624
P de N seedling	52.4	2240	532
Spy	41.0	2015	573
I	37.4	1286	485
French Crab	57.3	2456	434
II	51.5	2342	562

With Jonathan the most vigorous clonal stock, XII, has carried the heaviest crops over a period of years; the large trees on Pomme de Neige seedlings have not cropped as well as smaller trees on Malling II and trees on French Crab seedlings, although larger than those on Malling XVI again have not yielded as much. Only in 1961 did trees on French Crab seedlings surpass the yield of trees on Malling II.

With the variety Granny Smith early and heavy yields were obtained from the trees on Malling II and Spy. Only in 1961 did XVI outyield Spy, and in 1962 XII surpassed the yields of Spy.

Granny Smith

Stock	Girth cm. 1961	accumulated crops lb/tree	
		1938-62	1938-50
XVI	51.7	2414	622
XII	56.8	2311	645
Spy	42.4	2296	723
P de N seedling	47.7	1950	477
II	50.2	2827	787
XIII rootgrafts	40.0	1320	320

It will be seen that yields from trees on Pomme de Neige seedlings fall below those from Northern Spy, which with Granny Smith is a fruitful tree, but not as fruitful as Granny Smith trees on Malling II.

In spite of the fact that it would be desirable to use Malling XII for Jonathan trees and Malling II for Granny Smith for high production per acre, yet these stocks could not be recommended unless nurserymen would be prepared to combat woolly aphid which attacks these and other Malling rootstocks. With modern insecticides this is not an insuperable problem.

The Merton series of apple rootstocks

L.A. Thomas

This series of rootstocks was derived from a family of seedlings obtained by crossing Malling II with Northern Spy; they were raised at the John Innes Horticultural Research Institute at Merton, and in 1920 the four selections proved immune to woolly aphid were released under the numbers 789, 778, 779 and 793.

As one necessary character in apple rootstocks to replace Spy is immunity to woolly aphid these stocks were imported from East Malling Research Station for trial at Applethorpe.

Early nursery trials

L.A. Thomas

These trials were established with trees planted closely as in a nursery at 5 feet by 4 feet apart. With light pruning methods for Jonathan trees, four crops were produced within seven years and differences in growth and cropping were of such magnitude that early publication and release of these stocks was made to interested fruitgrowers.

Findings from two trials are given below, using Jonathan as scion.

First trial Stock	Accumulated crop. lb/tree	Weight of scion 1944. lb
793	78.5	9.6
789	75.4	7.8
Spy	40.0	5.0
Second trial Stock	**Average Crop/tree 1941-44**	**Average weight of tree. Northern Spy = 100**
778	32.0	266
779	40.0	197
Spy	21.0	100

From these two trials it was evident the trees approximately twice the size of those on Spy and capable of bearing heavy crops, and of early cropping behaviour, were now available. Fruitgrowers were invited to try these rootstocks on their orchards and were supplied with rootstocks. Later the Deciduous Sectional Group Committee, the local section of the Committee of Direction of Fruit Marketing, established a fruit tree nursery using Merton stocks and one private nursery is also now established. Something above 50,000 apple trees have been produced

on these stocks in this district and planted onto both new and old orchard sites.

The Queensland Department of Agriculture and Stock recommends Merton numbers 778 and 793 for planting in both new and old ground. Of later years New Zealand and South Africa have added Merton 793 to their list of select stocks. In New Zealand both 789 and 778 are susceptible to Phytophthora cactorum, and have been dropped because of this collar rot fungus. At Stanthorpe 789 is susceptible to crown gall infections and is now displaced from propagation in favour of 778 and 793.

Merton stocks with Delicious as scion

L.A. Thomas

An orchard size trial using Delicious as scion was planted in 1951 with trees 20 feet apart. This variety was chosen not only because of its great popularity, but because it is slower in coming into cropping with vigorous growth. As seen from the accompanying table, the early and heavy cropping induced by Merton 789 and 793 compared with other stocks is noteworthy and their size is greater than that of Northern Spy.

Delicious planted 1951

Stock	Girth cm. 1962	Crop/tree lb. 1962	Accumulated crop. lb/tree
Essfour	40.6	121	218
Own Roots	36.1	105	251
778	35.8	132	272
779	35.4	134	268
793	32.3	145	330
789	30.3	144	340
Spy	26.0	107	260
	Granny Smith guard trees		
778	33.9	149	339
793	32.7	135	297

This orchard trial has confirmed the value of Merton rootstocks as compared with Northern Spy and further has confirmed results found in closely planted nursery trials. It would then appear that closely planted trials, which occupy only small areas

are quite suitable for sieving out useful from non-useful rootstocks and for establishing the relative order for growth and cropping of particular rootstocks.

One further aspect of these nursery trials calls for comment. The early and heavy bearing of the Jonathan trees in such trials gave estimated yields on a per acre basis far in excess of that obtained in the district generally. From the fourth to their seventh year these trees yielded over 1000 bushels per acre on Merton 789 and 793 stocks, whereas Spy gave only half this crop.

Estimated bushels per acre 1941-44

Stock	Spy	789	793
Yield bus.	2180	4104	4272

As the district average yield is still below 200 bushels per acre it is disappointing that little effort has been made in Australia to introduce intensive systems of fruit growing. Reports from overseas countries, such as that from the Long Ashton Research Station's experiments prove that early and heavy cropping of dwarf pyramid trees planted 8 feet by 4 feet have outyielded trees spaced 24 feet apart after ten years.

As a further comparison of yields the table on the following page gives the average Jonathan crop on several rootstocks including the 1962 crop which was the heaviest on record. It will be seen that only on French Crab seedlings has there been a crop in excess of 1000 bushels per acre and then in the twenty-fourth year after planting.

There have been eighteen crops of fruit in the nineteen years of bearing, with no crop matured in 1949 owing to frost wiping out all fruits set. Calculations are based on the nineteen years of cropping.

Malling-Merton series of apple rootstocks

L.A. Thomas

This series of rootstocks was bred to combine the woolly aphid resistance of Northern Spy with qualities of vigour and fruitfulness found in the Malling Series. They are now numbered

101 to 115 after a double check on their immunity to woolly aphid; others in the series that failed the second check had already been imported by us; namely numbers 238 which became Malling XXV, 279 and 411.

These stocks with Jonathan as scion were planted in 1950 with trees spaced 20 feet apart in a randomized block layout. Four cropping years have shown stock 109 to be most fruitful, with little to separate numbers, 113, 114, 115 at this stage, so that two or more cropping years are needed to arrive at a first stage conclusion. However with 109 giving the largest girths and leading in cropping above that of 113 the next largest trees by 267 bushels per acre, it can be said that this is a most useful stock for Jonathan. Stock 109 has produced 470 bushels per acre more than Spy at twelve years.

	1962 Girth cm.	Crop lb. 1962	Accumulated crop 1950-62 lb/tree
109	38.1	274	641
113	36.1	219	534
114	35.6	200	471
115	34.8	228	558
279	33.9	209	531
XXV	32.2	190	464
411	30.8	214	519
Spy	28.8	178	453
107	28.1	125	339
108	27.9	155	385
110	26.2	143	397
111	26.0	128	347

Main Trial. Jonathan. Yield per acre. bus.
Calculated average yield per acre. bus.

Stock	1962 Crop	1959-62 Crops	1943-62 average yearly crop for 19 years
XII	847	520	349
XVI	947	578	343
French Crab seedlings	1025	599	323
II	765	489	308
Pomme de Neige seedlings	800	495	295
Spy	627	387	265
I	260	199	169

Own-rooted apple trees

L.A. Thomas

In our earlier experiments in 1944, we were interested in the production of apple trees on their own roots as at that time root-grafted trees were being planted and encouraged to become scion rooted. As little was known of the growth and cropping of such trees, as a first step we tested the ease of propagation of apple trees in layer beds and studied the root formation of two and three year old trees.

Surprisingly we successfully rooted 39 varieties of apple with this method, although references in literature made it appear to be most difficult.

The variety Delicious is the only one so far included in trials and its record is shown in the Merton Rootstock trial, where it will be seen that these trees are more vigorous, but slower in cropping than those on Merton 778.

Pear rootstocks

L.A. Thomas

The pear industry has largely been dependent upon seedlings for its rootstocks, except where quince stocks are used for obtaining dwarfed early fruiting trees. Characteristically pears on seedling stocks are strong growing trees which take a long period of time to come into full cropping; moreover these trees show a high degree of variability in size.

East Malling Research Station had produced some clonal pear stocks which gave earlier and heavier cropping than did seedlings. Among those imported by us and used in a nursery trial with Williams pear, clone D3 gave satisfactory growth and early cropping when compared with Pyrus Calleryana D6, the recommended stock of the New South Wales Department of Agriculture as will be seen from the table below. D3 shows promise of early and heavy cropping at the tenth year. (1941 planting).

Stock	Girth cm. 1950	Average total crop per tree 1945-50 lb.
P. Calleryana D6	24.9	23.3
East Malling D3	22.7	44.6

Although stock D3 and others gave promise of early fruiting, their difficulty of propagation, with a yield of 30 to 40 per cent. of rooted shoots, made it appear unprofitable to push these stocks into commerce.

Hence a search was made for pear stocks that would propagate as readily as apple rootstocks. With this in view extensive selections were made in Victoria and in the Stanthorpe district. From these collections, several stocks were found that rooted well in layer beds and one, clone 7, that roots readily in stools.

In a trial with Williams as scion, the data presented here show that clones 7 and 8 give a better performance than the trees on Kieffer seedlings, which are recommended stocks in Victoria.

Stock	Girth cm. 1961	Crop lb. 1962	Accumulated crop mean/tree. lb.
Keiffer seedlings	20.8	27	36
Clone 7	27.3	66	90
Clone 8	27.2	42	59
Clone E.M.D3	24.8	58	88

Further use of these clones is hoped for at least in this district, and further information of their usefulness for other leading pear varieties is planned.

OTHER TRIALS

Mineral deficiencies at Applethorpe

L.A. Thomas

A boron deficiency of apple trees described as apple measles was recognized and successfully controlled at Applethorpe in 1944 by using foliage sprays of borax.

The usual manifestation of boron deficiency in apple fruits, internal cork, is not often seen in the Stanthorpe district, but tree symptoms such as dying back of shoots, the development of bronzed bark with pustules and necrosis in bark tissues followed by cracking of bark are commonly observed.

Since our demonstration of boron deficiency, borax containing sprays have been applied annually, combined in one or more insecticidal sprays at 5 lb borax per 100 gallons, during the early part of the growing season, giving control of the deficiency in a very economical way.

Similarly zinc deficiency has been controlled with foliage sprays containing 3 lb zinc sulphate per 100 gallons applied at post blossom; whereas the usual method is to apply 25 to 50 lb zinc sulphate in the dormant season.

Maturity of fruit

L.A. Thomas

It was observed in 1954 that late applications of borax sprays used to overcome boron deficiency in apples, had the effect of hastening pre-harvest drop in Granny Smith apples. In trials using borax to test any change in maturity of apples it was found that physiological changes such as conversion of starch to sugar and decrease in acidity could be hastened with the application of borax and on the other hand urea sprays had an effect on delaying such changes. In this manner the date of harvesting fruits, Jonathan and Granny Smith, could be changed somewhat to facilitate the handling of a large crop or to take advantage of any high market price for early maturing fruit.

Gibberellic acid and fruit growth

L.A. Thomas

Our interest in the production of parthenocarpic fruits was stimulated by the work of Davison in New Zealand who produced full sized fruits of Sturmer Pippin with gibberellic acid in lanolin paste and of Strawberry Norman with sprays at a concentration of 400 p.p.m. But as his Cox's Orange Pippin fruits developed by the paste method were only half the size of normal fruits, it was thought that the size of the fruits developed might be related to the amount of cell division that had taken place, and this would give a measure of the effectiveness of gibberellic acid in promoting cell division in different fruit varieties.

Gravenstein and Johnathan varieties were used in our experiment; gibberellic acid at 400 p.p.m. was sprayed onto blossoms that had the anthers removed and styles decapitated at the balloon stage of opening which was one to two days before

full bloom. Full sized fruits of Gravenstein were produced which contained the same number of cells of the same size as open pollinated fruits. There was a slight swelling produced at the calyx end of these fruits, but otherwise they were of normal size, maturing at the same time and of a similar quality to normal fruits. Jonathan fruits produced with gibberellic acid were 0.8 times normal size and contained approximately 0.8 times the number of cells per fruit.

Whether a second treatment with gibberellic acid would cause further cell divisions in the young fruits of Jonathan needs further elucidation, but it would seem that with Gravenstein the normal number of cell divisions has occurred with one treatment of gibberellic acid. It is possible that gibberellic acid sprays could find a use in setting and developing a crop of fruit when conditions for insect pollination are poor or when a light crop of blossoms is present to ensure a full set of fruit.

PUBLICATIONS

Thomas, L.A. (1962). - Gravenstein and Jonathan apples produced with gibberellic acid. J. Hort. Sci. (In press).

TOBACCO INVESTIGATIONS - MAREEBA

Although the Tobacco Research Institute at Mareeba is located in the main tobacco-growing area of North Queensland, it is concerned with general problems of tobacco growing and tobacco science, irrespective of the areas to which they are relevant.

Plant breeding occupies a considerable part of the Institute's attention as none of the varieties in general use have been bred for Australian conditions, and all are susceptible to the very serious disease blue mould (Peronospora tabacina). Breeding of varieties resistant to this disease has now reached an advanced stage. An important part of the work at the Institute is concerned with plant nutrition, particularly nitrogen nutrition and the uptake of halides from the soil. Biochemical changes in the leaf as it approaches maturity and undergoes the curing process largely determine the quality of the leaf produced, and a detailed study of certain aspects of leaf biochemistry is in progress.

Arising from the results already obtained from the Institute the approach of the tobacco industry to tobacco culture and quality is now changing. The constituents which go to make up quality are being thought of as products of metabolism and therefore any environmental factor which will affect the plants' metabolism will have its associated effect on quality. The Institute is developing a team of workers whose fields will cover most phases of the plant's response to its environment. An understanding of these responses will provide basic information on the many types of tobacco that can be produced by one variety. This knowledge can then be used for the production of a specific type of tobacco if required, or for the understanding of the reasons why quality deteriorates under certain conditions.

PLANT BREEDING

The plant breeding programme continues to be largely concentrated on blue mould resistance. However, in the past season breeding for nematode resistance has also commenced. In addition a programme has been started, designed to improve quality and yield within crosses between commercial varieties. In the later stages of the breeding work all three programmes, namely, blue mould and nematode resistance, together with yield and quality improvements, may be combined.

Blue mould resistance

G.W. Geisler

Field resistance:- The resistant breeding material has been derived from three wild species of Nicotiana - (N. goodspeedii, N. debneyi, N. knightiana) which show resistance against blue mould. There is no evidence that crosses with these wild species result in different degrees of field resistance.

About 50 new varieties with field resistance against blue mould have been tested during the season on the Institute farm. Many of these lines show higher yields than Hicks, VG2 or White Mammoth which have been used as standard varieties in the trials. Information about the quality of the leaf from these lines is not yet available.

A further 150 mould resistant breeding lines have been selected and will be tested in replicated trials next season. These lines appear to have reached a yield level above that of Hicks.

Other breeding material, segregating for blue mould resistance is expected to produce 100 - 200 lines per season, for testing in replicated trials.

Seed-bed resistance:- A programme has commenced to develop varieties with seed-bed resistance to blue mould. Plants have been selected which remained free of blue mould after artificial infection of two-week old seedlings. The genetical basis of seed-bed resistance against blue mould is not yet understood. The plants selected as resistant will be used for crossing.

Nematode resistance

G.W. Geisler

Tests have been conducted of wild species with resistance to nematodes and screenings of a large number of varieties and breeding lines are in progress. Progress results are available. These indicate that some tobacco hybrids produced in the U.S.A. may be resistant enough to nematodes under North Queensland conditions to warrant their use in a breeding programme.

Yield and leaf quality

G.W. Geisler

Multiple crosses between commercial varieties have been made as the commencement of a programme for improving yield and quality especially under irrigation.

Laboratory testing of breeding material

G.W. Geisler

In addition to the breeding programme outlined above, investigations are in progress aimed at developing suitable methods for testing breeding material. A large scale breeding programme involves the field planting of a large area of tobacco. Under such conditions the mere physical task of carrying out routine observations on a large number of plants becomes a major task. With this in mind, investigations are in progress to determine whether some of the observations can be made on laboratory grown plants. Initially, these investigations deal with water relations; transpiration, leaf structure and root development of plants grown in water culture are all being studied. These investigations are relevant to the testing of new lines under irrigation conditions and are thought to give test methods which will assist with assessment of breeding material with regard to the environmental influence of irrigation conditions.

BIOCHEMISTRY

The studies on the metabolism of starch in green tobacco leaves have been continued and also extended to find the effect of light factors on starch synthesis and to find the enzymes responsible in senescing leaf for the depletion of starch. Work has been started on the cell-wall polysaccharides of the green leaf to determine their relationship to cell size.

Starch changes in developing and senescing tobacco leaves

N.K. Matheson and J.M. Wheatley

The quantitative changes in starch content during the growth and senescence of tobacco leaves have been followed. The starch content was low while the leaves were expanding, but rapidly increased after expansion stopped. The maximum was reached

when more than half the original chlorophyll content had gone. The starch content was then reduced rapidly and when the leaf was all yellow there was only a small quantity of starch and this remained when the leaf turned brown.

The viscosities, iodine affinities, β-amylolysis limits and granule sizes of isolated starch granules and the chain lengths of amylopectins at different ages of the leaves have been determined. The viscosities and iodine affinities increased with increasing age of the leaf and the β-amylolysis limits of the whole starch and chain length of the amylopectins were constant throughout the growth of the leaf. The number average granule size increased as the leaf matured until maximum starch content, and decreased as the starch content decreased. It is suggested that in tobacco leaves another starch accumulation pattern of longer duration than diurnal accumulation exists. The degradation of the starch resembles the breakdown of starch in spouting potato tubers and not that in germinating barley where amylases are the active enzymes.

The residue after ethanol extraction of leaves at different stages of growth was fractionated in to water-soluble material, a perchloric acid extract precipitated by iodine and a perchloric acid extract not precipitated by iodine but precipitated by ethanol. Glucan was only present in significant concentration in the perchloric acid extract precipitated by iodine and this had the properties of starch.

Paper chromatography indicated that the non-starchy extracts were composed of galactose, arabinose, xylose, rhamnose and uronic acid.

Diurnal-nocturnal changes in the starch of tobacco leaves

N.K. Matheson and J.M. Wheatley

The quantitative changes in starch content in tobacco leaves over diurnal-nocturnal periods have been determined for rapidly expanding, fully expanded and yellow leaves. The daily increase in starch content lessens as the leaves mature and senesce and the amount of non-metabolized starch in fully expanded leaves is much more than in rapidly expanding leaves.

The daily variation in starch is accompanied by no change in viscosity, chain length of the amylopectin and β-amylolysis limits, within the accuracy of measurement. The isopotential

iodine absorption of the starches is higher before dawn than in the late afternoon, implying a daily change in the amount of amylose or a change in the structure of the amylose. The average granule diameter in rapidly expanding leaves rises towards the end of the daylight period.

No evidence could be found for significantly high concentrations of any glucan besides starch and cellulose at any time of sampling.

The influence of daylength, shade and continual darkness on the starch content of attached tobacco leaves

N.K. Matheson and J.M. Wheatley

Tobacco plants have been grown in short, (7½-8 hrs) medium (12½-13 hrs) and long days (17-17½ hrs). The artificial light, which was supplementary to daylight in the long days was 1200 foot candles at the leaf surface. Short day length reduced the final height of the plants and the number of leaves relative to medium daylength plants and the chlorophyll content was higher and chlorophyll disappeared from the leaves at a later time. Maximum starch content was slightly lower in short day plants and starch depletion in the leaves took place at the same time in both short day and medium day plants. Thus starch disappeared from the short day leaves before chlorophyll, in contrast to medium day plants where starch is still being synthesized when chlorophyll content is approximately half the original value. Long day plants did not differ from medium day plants.

Plants grown in continuous shade were very low in dry weight per unit area relative to full sunlight and the time to flowering and time to senescence of individual leaves was markedly increased.

Starch depletion from fully expanded leaves of whole plants placed in total darkness was much slower than previous reports on detached leaves.

Water soluble polysaccharides of tobacco leaves

N.K. Matheson

Fully expanded tobacco leaves have been extracted with dilute oxalic acid and the extract fractionated on "Sephadex" and the polymer fraction separated into two polysaccharides on a DEAE

cellulose column using dilute hydrochloric acid, acetic acid or dilute sodium hydroxide as eluants.

Protein investigations

J.M. Wheatley and N.K. Matheson

In order to study the enzymes involved in starch metabolism, leaf samples at various stages in development have been converted to acetone powders. A satisfactory method of chromatographic separation of the protein fraction has been developed, avoiding the denaturation of the protein by polyphenol oxidase oxidation products.

PLANT NUTRITION

Work is continuing on the flat leaf problem. Two lines of investigations are in progress: (i) soil studies designed to provide information on the release of utilization of nitrogen under conditions of irrigation; (ii) chemical investigations of leaf components to follow the disappearance, mainly after curing, of leaf colour.

Soil nitrate studies

W.J. Lovett

Incubation techniques are being used to study the production of ammonia and nitrate nitrogen by a series of soils, both fumigated and non-fumigated. Ammonium sulphate has been added to some of the soils and its oxidation is being measured at time intervals. Results to date indicate that: (i) with decreasing soil moisture content the oxidation of ammonia to nitrate is inhibited; ammonia accumulates in the soil; (ii) nitrification rate increased with increasing temperature between the range of 21°C - 31°C. This temperature effect is not uniform for all soils studied. At 21°C one Burdekin soil type showed no appreciable utilization of added ammonia nitrogen over a period of three months, whereas another showed about 40 per cent. utilization in the same time. Basaltic soils from the Mareeba aerodrome area used up to about 40 per cent. of the added ammonia in a little over 1½ months; (iii) incubation of the basaltic soils at increasing temperatures from 32°C - 40°C results in a decreased rate of ammonia oxidation; (iv) the concentration of ammonium sulphate added influences nitrification in both Burdekin and basaltic soil. With increasing concentration from 25→50→100 ppm

there is a corresponding decrease in nitrification rate.

A study of the effect of fumigation on the soil nitrification cycle has shown that the whole process is slowed and there is a reduction in the oxidation of ammonia to nitrate. This reduction in soil nitrate levels could possibly be of importance in its effect on leaf quality.

The pH of the soils examined so far has ranged mostly between 6-7. It is therefore unlikely that unfavourable pH is responsible for the inhibition of nitrification in "flat leaf" soils.

Field experiments have shown that there is a tendency for nitrate to accumulate in the top few inches of a soil following a period of dry weather. This appears to be due to capillarity and is more pronounced under conditions of furrow irrigation; there being a concentration of most nutrients in the hills. This may offer a partial explanation for the increased growth observed after rainfall. The soil in the hills receives its first good soaking resulting in a leaching of nutrients to the root zone. The phenomenon of increased growth following rainfall has been a subject of study during this season and analyses of rainfall have not shown the presence of significant amounts of nitrate.

In areas of coarse sandy soil it has been found that much of the nitrogen applied as fertilizer is leached from the root zone. This results in a premature ripening with the production of an immature type of leaf. Under such conditions it may be advisable to apply the fertilizer through the spray line at several times during the growth of the plant rather than as one application at the beginning of the season. Investigations on this technique are in progress.

Throughout the season soil nitrogen analyses have been made and the results obtained correlated with crop appearance. The fall in soil nitrogen levels resulting in a yellowing of the crop are usually evident from the analyses some time before the crop shows symptoms of a shortage. Conversely high soil nitrogen levels are clearly indicated by analyses. Work is in progress to determine whether the soil analyses figures can be used for applying remedial action in the case of either high or low nitrogen levels.

Chemical investigations

Lesley C. Justins and W.J. Lovett

Work at present is concentrated on (i) methanol and (ii) acetone extraction of the cured leaf. These extractions remove virtually all the colour from the leaf. The absorption spectra of each extract will be examined and the polyphenolic content of (i) will be determined by paper chromatography. Attempts are being made to examine the carotenoids and colourless polyenes contained in extract (ii).

In addition, estimations of tocopherols, ascorbic acid and some other organic acids will be made on "flat" and "normal" leaf to determine whether these substances may have some protective action on the pigments. The concentration of the above substances and the pigments, during the life of the leaves and the curing and bulking process will be followed. It may then be known whether the loss of colour by flat leaf is due to a reduced pigment synthesis or an accelerated pigment breakdown.

PUBLICATIONS

Goodall, D.W. (1961). - Objective methods for the classification of vegetation. IV. Pattern and minimal area. Aust. J. Bot. 9: 162-96.

Lovett, W.J. (1961). - Progress Report on flat leaf problem. Aust. Tob. J. 2: 18, 19 and 29.

Matheson, N.K., and Wheatley, J.M. (1962). - The effect of some extraction solvents on the structure of the starches from tobacco leaf and potato tubers. Aust. J. Biol. Sci. 15: (In press).

Matheson, N.K., and Wheatley, J.M. (1962). - Starch changes in developing and senescing tobacco leaves. Aust. J. Biol. Sci. 15: (In press).

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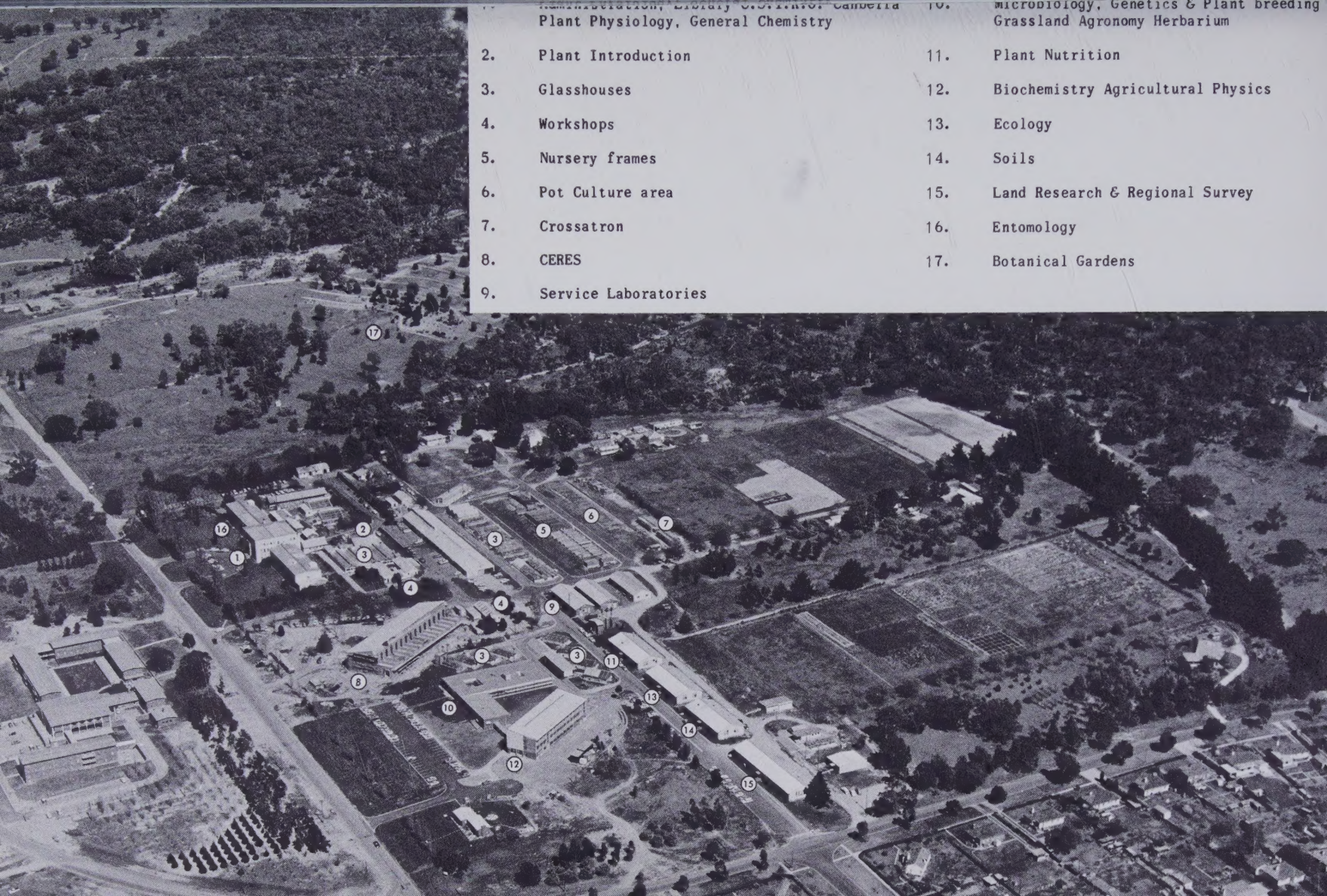

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